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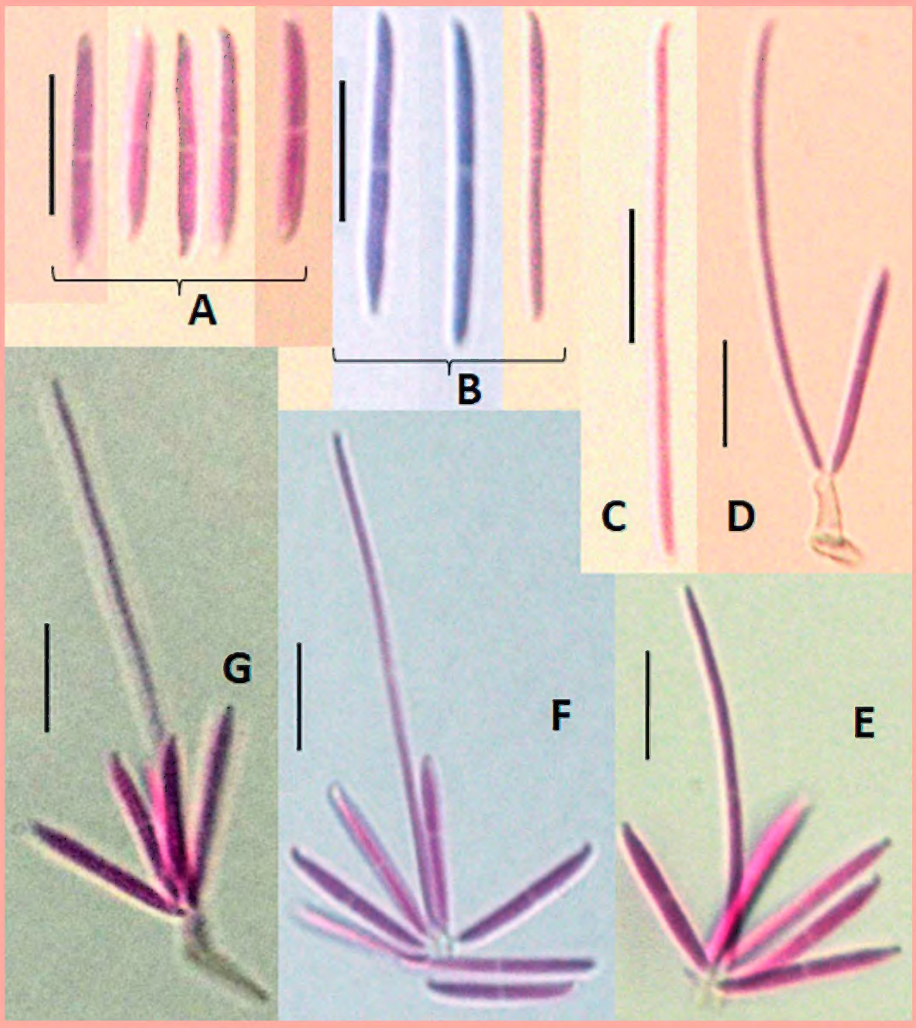

***Castanediella diversispora* sp. nov. from the Brazilian Atlantic Forest**
Costa & al.— FIG. 1, p. 65

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publication date for volume one hundred thirty-two (4)

Mycotaxon *for* October–December 2017, (i–xii + 707–1001)
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Nomenclatural novelties and typifications proposed in Mycotaxon 133(1)

Alternaria crassoides (Davis) Gannibal
[MB 822404], p.40
Alternaria dolichi (T.Y. Zhang & G.Z. Zhao) Gannibal
[MB 822503], p. 40
Alternaria heteroschemos (Fautrey) Gannibal
[MB 822405], p. 40
Alternaria juncicola (E.G. Simmons) Gannibal
[MB 822407], p. 40
Alternaria nimbyae-dianthi Gannibal
[MB 822505], p. 40
≡ *Nimbya dianthi* T.Y. Zhang & G.Z. Zhao 2005
non *Alternaria dianthi* J.V. Almeida & Sousa da Câmara 1903
Alternaria nimbyoides Gannibal
[MB 822504], p. 40
≡ *Nimbya euphorbiicola* W.Q. Chen & T.Y. Zhang 1997
non *Alternaria euphorbiicola* E.G. Simmons & Engelhard 1986
Alternaria rhapontici (Nelen) Gannibal
[MB 822406], p. 40
Arachnophora longa Fryar & K.D. Hyde
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Calogaya qinghaiensis B.G. Lee & Hur
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Caloplaca zeorina B.G. Lee & Hur
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Castanediella diversispora P.M.O. Costa, Malosso & R.F. Castañeda
[MB 824478], p. 64
Diploschistes wui A. Abbas, S.Y. Guo & Ababaikeli
[FN 570518], p. 144
Ellisembia hainanensis M. Qiao & Z.F. Yu
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[MB 824948], p. 198
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[FN 570491], p. 15
Inocybe austrofibrillosipes Matheny, Bougher & G.M. Gates
MB 824698, p. 173
≡ *Inocybe fibrillosipes* Matheny, Bougher & G.M. Gates 2017,
nom. illegit., non E. Ludw. (2017)

Inocybe fulvotomentosa Matheny, Bougher, R. Rob. & K. Syme
[MB 824699], p. 173
≡ *Inocybe mallocyboides* Matheny, Bougher, R. Rob. & K. Syme 2017, nom. illegit., non E. Ludw. (2017)
Rhexoacrodictys broussonetiae Xiao X. Li & Z.J. Xiao
[FN 570519], p. 150
Rosellinia jiangxiensis Wei Li bis & L. Guo
[FN 570498], p. 31
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Teuvoa alpina Q. Ren
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[FN 570492], p. 190
Varicellaria emeiensis Q. Ren
[FN 570520], p. 72
Verrucaria eminens B.G. Lee & Hur
[MB 815075], p. 121

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The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this quarter.

André Aptroot
Alan W. Archer
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Cvetomir M. Denchev
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Ek Sangvichien
Hurnisa Shahidin
Ewald Sieverding
Gladstone Alves da Silva
Jan Vondrák
Xin-Yu Wang
Hai-Sheng Yuan
Xiu-Guo Zhang

Errata from previous volumes

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p. 892, line 32	for: SWAT15-1560	read: SWAT000136
p. 895, line 1	for: SWAT16-0021	read: SWAT000137

Volume 132(4)

p. v, line 18	for: Xiao-Man Li	read: Xiao-Man Liu
p. v, line 21	for: Xiao-Man Li	read: Xiao-Man Liu

From the Editor-in-Chief

Mycotaxon 133(1) presents 26 papers by 108 authors (representing 19 countries) and reviewed by 42 peers.

Within our pages are 17 species new to science representing *Arachnophora* from Australia; *Buellia, Calogaya, Caloplaca, Diploschistes, Ellisembia, Graphis, Rhexoacrodictys, Rosellinia, Teuvoa, Tuber, Varicellaria,* and *Verrucaria* from China; and *Castanediella* from Brazil. Replacement names are proposed for two Australian *Inocybe* species and two species of *Alternaria*, with five new *Alternaria* combinations also proposed.

Species range extensions (many with keys to the genera) are reported for species representing *Morchella* (Pakistan), 8 polyporoid genera (Algeria, Mexico, Taiwan), and 17 lichen genera (mainland China, Korea, Vietnam). Clarifications for hosts and distributions for two *Hyalopsora* rusts and two black truffles in China and the summary of an updated mycobiota devoted to AM fungi in Brazil's Atlantic Forest are additionally presented.

Finally, on the next pages we have the sad duty of offering brief biographies and memories of three exceedingly productive mycologists—José Miguel Barea, Gary Lincoff, Franz Oberwinkler—who passed away during March and April.

Of what use range extensions? For years, Mycotaxon has published new records of species extending a known range and 'filling in the dots' on the distribution map. Last year we changed our requirements for range extension papers to ensure that authors describe their actual collections and NOT recapitulate previously published descriptions: we now require original specimen-based descriptions, specimens examined section, illustrations, **and** "a brief discussion of similarities/differences between the newly collected specimens and previously published descriptions and data from the same species" (Mycotaxon 132(1): ix–x).

In a Mycotaxon range extension paper, the terms **specimens** and **species** are not interchangeable. The technical description should cover only characters actually observed in the collected **specimens**. Following the description appear observations of the habitats/substrates/associates of the **specimens** (NOT species). After the list of specimens examined, the first sentence(s) should compare the **specimens** with the type descriptions of the identified **species** (noting similarities/differences). Only then should authors compare the **species** with other **species** to rule out look-alikes. All statements in the final remarks section should be supported by a text reference or references.

The most scientifically significant contribution of a range extension paper is the comparison between the newly examined specimens and those described in the **type** description (i.e., the 'protologue'), as it provides information that might eventually form the basis for a new species.

Mycotaxon style & the ampersand—Authors who recall Mycotaxon's 20-page author instruction PDF may wonder why these days we "suddenly" change a style without a word of explanation. Your over-worked editors have found it easier simply to make small stylistic changes without explaining why. Style—often regarded quixotic at best—is a matter of editorial preference, if not eccentricity. In returning my final editorial corrections, I have found it much quicker to make the changes myself, often without a word of explanation but merely highlighting in blue those not to be changed. Shaun usually DOES provide explanations in his nomenclatural review notes, but there may be instances where a revision may seem unnecessary to a perplexed author.

For the past several years, observant authors may have noticed an ampersand (&) placed before the last author on their title page. However, the number of submissions arriving with only commas separating a list of several authors suggested that the symbol is unnecessary and serves no useful purpose. Henceforth, only commas should separate a list of three or more authors. Norvell & Pennycook do, however, retain the ampersand between two author names.

Do not worry about the fate of the lowly ampersand: we are making up for eliminating '&' from the author list by changing the 'et al.' construction to '& al.'!

CrossRef problems—We have detected more glitches in CrossRef, not yet updated in our instructions. Those typing text into CrossRef in order to obtain DOI numbers should not enter apostrophes or letters with diacritical marks into the system. If you do not receive a DOI for a publication that you know should have one, substitute plain font (type "Jose" instead of José) and delete apostrophes ("ODonnell" for O'Donnell) to obtain your number. We devoutly hope that CrossRef repairs its algorithms before we have to revise our author instructions again.

Submission procedures have changed: For bookkeeping purposes, manuscript authors are now asked to send all text and illustration files with the completed 2018 submission form to **both** the Nomenclature Editor and the Editor-in-Chief prior to accessioning. All forms, including the reviewer forms, have changed; be certain to send the 2018 expert comments forms to your reviewers. Please DELETE all older [read: "antiquated and no longer acceptable"] Mycotaxon forms from your files.

Warm regards,

Lorelei L. Norvell (*Editor-in-Chief*)
18 April 2018

In remembrance

Courtesy of Concepción Azcon de Aguilar

José Miguel Barea Navarro (1942–2018]: Professor Barea, a world leader in arbuscular mycorrhizae honored throughout Spain, Europe, and Latin America, was born in 1942 in Granada, Spain, and died unexpectedly in Granada at age 76 on 3 April 2018

Barea obtained his pharmacist (1965) and doctoral (1968) degrees from the Department of Soil Microbiology at the Experimental Station of Zaidín (EEZ), University of Granada. His doctoral thesis marked the beginning in Spain of "bio-fertilizer" research in the phosphorus cycle of soil and plants. Serving as Adjunct Professor of Microbiology at Granada until 1972 and Professor of the International Course of Vegetal Biology during 1968–2012, José Miguel launched the International Course in Plant Biology Edaphology (influence of soils on plants) and taught honors courses at the Universities of Granada and Murcia on agricultural biology, sustainable use and protection of the soil in Mediterranean environments, and research & advances in microbiology in addition to 50 national and international postgraduate courses in Spain, Brazil, Argentina, Chile, Cuba, Mexico, and Venezuela, supervising 33 doctoral theses along the way.

Promoted in 1984 to Research Professor of Spain's Higher Council for Scientific Research (CSIC), which he directed for nine years (1989–1998), Barea also served as consultant to the United Nations Food & Agriculture Organization (FAO) and the International Atomic Energy Agency (IAEA) and the International Foundation for Science. In 2012 Professor Barea was admitted as Full Member of the Academy of Mathematical, Physical-Chemical, and Natural Sciences of Granada, delivering "Mycorrhizas and Climate Change" as his entrance lecture. His primary research focused on basic, strategic, and applied studies of microorganisms beneficial to plants in agriculture and natural ecosystems, with special emphasis on arbuscular mycorrhizal fungi (fungus-plant symbiosis) and bacteria that promote plant nutrition and health. He oriented his research towards the recovery of degraded ecosystems and conservation of threatened and endemic flora, seeking alternatives to the excessive use of agrochemicals and fungicides in agriculture.

In 2013 Chile's University of La Frontera awarded José Miguel its prestigious Rector's Medal for pioneering work on mycorrhizae in Chile and Latin America and his activities as founding member of the Doctorate in Natural Resources Sciences and the Scientific Nucleus in Natural Resources (BIOREN-UFRO). He was also

Source: www.ideal.es/miugr/

The Professor relaxing (temporarily) in Granada

awarded a research prize from the Caja General de Ahorros de Granada (1980) and honorary professorship by the Faculty of Agronomy at Argentina's University of Buenos Aires (2004). Professor Barea also served as President of the Organizing Committee for the 4th European Conference on Mycorrhiza (Granada 1994) and of the 5th International Conference on Mycorrhiza (Granada 2006).

ICOM5
Dr. José Miguel Barea
El buque insignia del Realejo
La cruz de la Corrala de Santiago es una de las más famosas de esta fiesta popular ■ Los vecinos colaboran activamente en su organización

Fritz Oehl

Above—left: An enthusiastic Fritz Oehl welcomes the esteemed host of ICOM5 to Brazil's ICOM6; right: José Miguel performs with the Coro de Maria Auxiliadora on the balcony during the Andalusian festival Día de la Cruz. Below—left: The Día de la Cruz courtyard; right: the infamous newspaper article naming both long-standing (José Miguel, top right) & temporary (Fritz, below José) chorus members.

Fritz Oehl

A genial José Miguel in early 2018

Directing or participating in more than 30 research projects throughout Spain and the European Union (and integrating Research Groups from France, Spain, Morocco, Algeria, and Tunisia) Barea was the author of 200 scientific papers and chapters in 41 international books; ResearchGate [www.researchgate.net/profile/Jose_Barea] cites 121 research items.

In announcing Barea's passing, Estación Experimental del Zaidín Director Barón noted that Barea's disciples, scattered all over the world, were attending the funeral, adding, "José Miguel was the person who opened the station. I arrived at seven in the morning. He loved his work and also communicated very well what he was investigating and what he was doing.... He was still working until two weeks ago.... José Miguel's death came as a shock to his friends and colleagues, all of whom will miss his friendship, generosity, intelligence, gallantry, good humor, and scientific leadership."

Mycotaxon received the sad news from Dr. habil. Ewald Sieverding [Hans-Ruthenberg Institute, University of Hohenheim, Stuttgart]: "Prof. Dr José Miguel Barea, Granada-Spain, died three days ago. He was a great researcher and teacher, and promoted mycorrhizal studies and supported young researchers particularly in Central- and South America. He was only 76 years old. I lost a great friend." In responding with additional photos, Dr. Fritz Oehl [Agroscope, Bern] reminisced, "José Miguel and I met about fifteen years ago. He was host of one of the first ICOM's in 2005 in Granada and presented in excellent manner the Andalusian lifestyle, the music, dances, and food (including the famous tapas, which I confused with capas—wall layers—so that during my one-hour lecture I kept talking about about tapas...). He was a member of the Coro de Maria Auxiliadora in Realejo and regularly sang 'Sevillanas' with his friends. I later had the chance to work several times on weekly to monthly bases in Granada with his great, lovely, and lively research group. I once sang downtown with José-Miguel and his chorus on the day of the crosses (3 May), one of the most important holidays in Granada. The next day I appeared together with José-Miguel and all the real chorus members of the Chorus in the newspaper." Finally, in 2009 for ICOM6, it was my honor to pick up the famous host of ICOM5 at the Belo Horizonte Airport. Small anecdotes, but nice memories."

Mourning his passing, Director Dr. María de la Luz Mora commented, "José Miguel was an example for all of us. A great gentleman, funny, a little crazy, but a great scientist." It seems fitting to close with that great scientist's expressed desire that science receive: "consideration and institutional and financial support from the governments. This would allow incorporation of young researchers with new ideas and a great abundance of energy and enthusiasm. Of course, I hope that in Andalusia and the rest of Spain high-quality research will be developed that will help advance

knowledge at the global level but that will also result in society subsidizing science and improving the environment. It will be important to cooperate with private companies that would come to value technological advances and their applications, thereby creating opportunities for employment." Vaya con Dios, José Miguel.

—Lorelei Norvell

Internet sources: http://www.ideal.es/miugr/fallece-jose-miguel-20180404221350-ntvo.html
Lorena Espinoza Arévalo: www.ufro.cl/index.php/noticias/12-destacadas/
Feliciano Robles Blanco: https://granadinosilustres.wikispaces.com/

'Millenium' mushrooms: Breitenbush, Oregon, 1999

Source: www.harrodblank.com

This photo of a 2011 Woodlawn Cemetery mushroom foray in the Bronx headlined Lincoff's New York Times obituary.

Alan Zale (source: www.nyt.com)

Welcome to www.garylincoff.com

Gary Henry Lincoff (1942–2018]: A philosophy major and law-school dropout whose enthusiastic devotion to fungi transformed him into the "Pied-Piper of Mushrooms" died unexpectedly of a stroke at age 75 on March 16 in Manhattan, New York. Gary Lincoff, born in Pittsburgh, Pennsylvania, to optometrist Leonard Lincoff and the former Bette Forman, is survived by wife and graphic designer Irene Liberman, son Noah, and brother Bennett.

After obtaining his BA in philosophy from the University of Pittsburgh in 1963 and escaping law school at George Washington University, Gary met his wife in 1967 while pursuing graduate studies in English Lit at Pittsburgh. The couple moved to New York City in 1968, where he backed into mycology while trying to figure out how to survive on wild food collected in New York City's Central Park. After sampling "acorn burgers, pokeweed shoots, and Juneberry pies" (Andy Newman, New York Times, 23 March 2018), Gary became smitten with mycology after eating nine wild mushrooms picked during his first walk with the New York Mycological Society. After submerging himself in the study of fungi in the 70s, Gary convinced the New York Botanical Garden to offer a mushroom course to the public, with him as instructor. Dr. Roy Halling (Curator of Mycology, NYBG Institute of Systematic Botany) noted that Lincoff taught classes and led forays right up to the end. His fatal stroke occurred shortly after holding what was to be his last winter tutorial on mushroom genera and species at the COMA [Connecticut-Westchester Mycological Association] 'Mushroom University.'

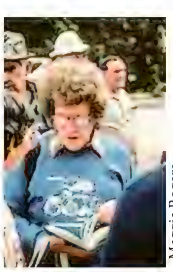
The 1977 Lincoff & Mitchel Toxic and hallucinogenic mushroom poisoning—a handbook for physicians and mushroom hunters proved an invaluable resource for poison centers and mushroom identifiers alike; Gary autographed my copy with "The old saying was 'Beware of Greeks bearing gifts;' the new saying is 'Beware of friends bearing Giftpilze.'"

Next came Lincoff's groundbreaking (and controversial) 1981 The Audubon Society Field Guide to North American Mushrooms. The enthusiasm with which mushroomers greeted 756 color photographs of mushrooms (most illustrated for the first time) was soon drowned out by purists who heartily disliked photos bearing only 'common' names. Vituperation soon fell on Gary, who protested that the naming faux pas was dictated by the Audubon Society, which refused to realize that serious mushroomers (unlike birders) used only Latin to name their species. He had pointed out in vain that most species photographed did NOT have common names, but in the face of Audubon inflexibility, he set about zestfully inventing 'common' names. I spent a few weeks printing tiny Latin names onto Avery labels that I cut and pasted onto the photos, considerably thickening the volume (inscribed by Gary in 1982 with " To Lorelei, Hope you like this guide and find it useful"). Gary thoroughly enjoyed inventing 'Dirty Trich' for the poisonous *Tricholoma pardinum* and 'Sweet Tooth' for *Hydnum* (as *Dentinum*) *repandum,* but Dr. Daniel Stuntz was less amused by 'Stuntz's Blue Legs' for *Psilocybe stuntzii.* As the hue and cry over nomenclature reached deafening proportions, Gary climbed the battlements to proclaim that common names were a good thing, and besides, just how immutable was Latin-based nomenclature, anyway? [Touché.] In the long run, it made little difference. Nomenclaturalists and pothunters alike riffled his photos for something resembling the specimen in hand, turning diligently to the onion skin pages to compare their find with the technical description listed by a Latin name complete with author epithets, family, and order. The book continues to be a rousing success, as its 31 printings attest.

Lincoff's international renown as mushroom guru evolved from his association with the North American Mycological Association [NAMA]—which he served as second president for nine years (1979–1988), leader of mycological treks through

Linnea Gillman

Linnea Gillman


Maggie Rogers

Gary Lincoff on foray: (from the NAMA files on newmexicomyco.org/): Left: questioning Rolf Singer about any new segregate genera in1984; Center: congratulating New Mexico's Chuck Barrows on becoming a *Boletus* at Canaan Valley in 1985; Right: consulting with Aileen Stanley regarding the absolute dearth of Idaho mushrooms before the 1986 Priest Lake foray (during which it poured buckets—too late to produce mushrooms, of course).

Scott Redhead

Source: wpamushroomclub.org/lincoff-foray/

Left: During the 1998 Harry D. Thiers Foray at Asilomar, Gary and Lorelei resume their on-going wrangle over mushroom nomenclature—common and otherwise. Right: Gary expounds on fungi at the 2017 Western Pennsylvania Mushroom Club annual foray, renamed after his death to the The Gary Lincoff Memorial Foray to be held in 2018 on September 15.

more than 30 countries ("on every continent except Antarctica"), and participation in almost every foray held across America. He was awarded the 1986 NAMA Award for Contributions to Amateur Mycology, an award renamed as The Gary Lincoff Award for Contributions to Amateur Mycology in 2015; he was also the first recipient of the Mycological Society of America's Gordon & Tina Wasson Award in 2017.

Gary bounded into my life the first time at the 1982 Southern Idaho Mushroom Association Priest Lake foray. Every year thereafter he officially (or otherwise) entertained Oregon Mycological Society meetings and forays: one year he cooked and served a delicious *Amanita 'calyptrata'* to willing OMS forayers (definitely flaunting our dictum that NO amanita was safe to eat), a custom begun at Colorado's 'Edibility Unknown' party at the Telluride Mushroom Festival he helped establish with Andrew Weil, Emmanuel Salzman, and Paul Stamets in 1981. Before the 1986 OMS Fall Foray Gary joined our Oregon *Cantharellus* Study Project crew in Mt. Hood's Bull Run Watershed to select promising chanterelle sites. The square 64 m^2 control 'Lincoff Plot' proved so prolific that we soon changed its name to Hell Plot, as we struggled to measure each of 100+ fruitbodies every two weeks from May to December without touching the ground, thereby establishing that individual chanterelles do 'live' a VERY long time. Then there was the 1990 Whistler (British Columbia) NAMA Foray when Vancouver Mycological Society's Paul Kroeger 'rudely' interrupted a slightly tedious and definitely long-winded hand-puppet performance to yank protesting puppeteer Lincoff off the stage by the neck with a long hook. Gary departed with good grace, and the hooting crowd loved it.

Very few mushroomers warrant a New York Times obituary, but that was Gary—a born raconteur and always memorable. We will all miss the mushrooming gadfly of Manhattan.

—Lorelei Norvell

Additional Internet source: http://wpamushroomclub.org/lincoff-foray/

Source: https://www.zobodat.at/personen.php?id=64692

Franz Chr. Oberwinkler (1939–2018]: Prof. Dr. rer. nat. Oberwinkler, born on 22 May 1939 near Salzburg in Bad Reichenhall of Germany's Upper Bavarian alps, died after a short illness on March 15 in Tübingen. He is survived by wife Barbara, sons and daughters Johannes, Clemens, Michaela, and Claudia and their spouses, and ten grandchildren. News of the death of the world-renowned heterobasidiomycete specialist rapidly reached Mycotaxon in a series of Email forwards. Prof. Marc-André Selosse [Museum national d'Histoire naturelle, Paris] sent "the sad news of the death of a great German mycologist and my friend, Franz Oberwinkler" to Mycologia Europaea, accompanied by details from Dr. Michael Weiß [Steinbeis Innovations GmbH, Germany], Oberwinkler's former student and colleague, who wrote that although a fast-growing and inoperable brain tumor greatly impaired his abilities to communicate during his last six weeks, Prof. Oberwinkler remained fully aware until he died. "He was a great teacher and inspired many. I owe him much."

After earning his PhD in 1965 at the Ludwig Maximilian University of Munich under the supervision of Josef Poelt, he became a research assistant and lecturer at the university's Institute of Systematic Botany in 1967, advancing to professor in 1972. In 1968–1969, he also served as Scientific Expert for the Food and Agriculture Organization at the Insituto Forestal Latino-Americana in Mérida, Venezuela. In 1974 he was appointed Chair of Systematic Botany and Mycology at the University of Tübingen, serving as Director of the Botanischer Garten der Universität Tübingen until his retirement in 2008. After his retirement Oberwinkler remained an active Professor Emeritus of the university's Organismic Botany Group. In 2002 as Editor-in-Chief Oberwinkler founded Mycological Progress, a journal he continued to edit until his death.

Although specializing in heterobasidiomycetes, Oberwinkler researched the morphology, ecology, and phylogeny of all basidiomycetes, co/authoring 340 publications between 1962 and 2010. Two projects funded by the German Research Foundation were "*Sebacinales* distribution patterns in plant communities" and "Systematics of plants and fungi." Those interested in Oberwinkler's impressive list of 509 research items [including two books: Basidiolichens (2012) and Das neue System der Basidiomyceten (1977)] should consult his ResearchGate site —www.researchgate.net/profile/Franz_Oberwinkler—citing the 2017 paper published only five months ago in Nova Hedwigia by Kirschner, Oberwinkler & Hofmann describing a new species of *Globulisebacina* from Taiwan.

An extremely cursory glance through IndexFungorum and a few of the papers posted on ResearchGate suggests it may take some time to calculate the actual number of taxa citing "Oberw." as author or co-author. After thirty minutes (and consulting fewer than 30 papers) I counted one phylum (*Entorrhizomycota*), two subphyla, 8 classes, 22 orders, 12 families, 23 genera, and 69 species—an estimate that undoubtedly falls far short of the actual number. Wikipedia [https://en.wikipedia.org/wiki/Franz_Oberwinkler] lists five names honoring Oberwinkler: *Amanita oberwinkleriana, Sphaerobasidioscypha oberwinkleri, Thecaphora oberwinkleri, Uromyces oberwinklerianus,* and the genus *Oberwinkleria.*

www.ima-mycology.org/congresses/imc-5

International Mycological Congress V—Canada, 21 August 1994: Franz Oberwinkler is announced as incoming President of the International Mycological Association at the final General Assembly of IMC V, held on the campus of the University of British Columbia in Vancouver.

Oberwinkler's mycological reputation is formidable and far-reaching. He participated in all International Mycological Congresses, serving as President of the International Mycological Association from 1994–1998. A world-traveler, he also visited many mycological societies, and was made an Honorary Member of the Mycological Society of America in 2005. Five years later, he was awarded the De Bary Medal for outstanding career research in mycology, at the 2010 IMC in Edinburgh, Scotland. The nominating letter by Michael Weiß and Dr. Robert Bauer [1950–2014] noted his contributions to all areas of fungal research: "Besides his overwhelming scientific output, he is a great teacher and many of his scholars have become influential mycologists as well. Franz Oberwinkler had a major impact on our understanding of the systematics of basidiomycetes. Inspired by a deep interest in detailed morphology and anatomy of basidia and basidiocarp ontogeny and their comparative analysis his work revolutionarised basidiomycete systematics at the higher levels, by investigating morphology, physiology, and genetics to clarify the primary evolutionary trends in basidiomycetes. Our modern view on *Basidiomycota* is highly influenced by his work." Subsequently in 2013 Oberwinkler was among the first nine mycologists named as IMA Fellows for outstanding contribution to the advancement of mycology at an international level.

I was fortunate to encounter Prof. Oberwinkler personally several times over the years, initially finding him somewhat reserved but courtly. Knowing his reputation, I particularly appreciated his kind words during the 1999 International Botanical Congress mycology poster sessions in St. Louis and his gracious interest in the biodiversity of epigeous ectomycorrhizal basidiomycetes in Oregon's Douglas-fir

IMC VIII pre-congress forays—Australia, 19–20 August, 2006: *Top left:* Daintree Rainforest Foray. Barbara & Franz Oberwinkler and two other hardy interlopers scout the river bank well beyond the crocodile DANGER sign. Lake Barrine Mesa Highlands Foray. *Top center:* A deadly taipan races across the road—fortunately on the other side of our van windshield. *Top right:* Hovering on the road, Bernhard Oertel, Oberwinkler, and Meredith Blackwell consult our guide regarding snakes in the Bush. *Center:* Barbara greets a friendly wallaby. *Bottom:* Fourteen brave forayers—**front row:** three congenial family members (Australia), Lorelei Norvell (USA), Dmitry Schigel (Finland); **middle row:** Scott Redhead (Canada), Fungi Perfecti (USA), Cheryl Grgurinovic (Australia); Paul Stamets & Dusty Yao (USA), Bernhard Oertl (Germany), Meredith Blackwell (USA); **back row:** Barabara & Franz Oberwinkler (Germany) + one giant termite mound (Queensland).

www.ima-mycology.org/congresses/imc-8

IMC VII—Cairns conference center, 23 August 2006. The Oberwinklers shepherd Dilzara Aghayeva (Azerbaijan) through a late afternoon social.

forests at the 2002 IMC7 in Oslo. Much more relaxed during the 2006 IMC8 Daintree and Lake Barrine forays at Cairns, he and his wife Barbara thoroughly submerged themselves in the wilds of Queensland, roaring right to the rivers edge whilst ignoring the STAY BACK crocodile alert signs, feeding wallabies, inspecting giant termite mounds, hiking past a towering giant Banyan on Lake Barrine, and looking for tree kangaroos by flashlight under the southern cross. During a quiet chat between lectures, he exposed his mentoring skills when he introduced me to an Azerbaijani student (now Dr.) who would eventually contribute to Mycotaxon.

www.ima-mycology.org/congresses/imc-9

IMC IX closing ceremony—Edinbrugh, 20 August, 2010: Mike Wingfield (South Africa) & retiring IMA President Pedro Crous (The Netherlands) greet the new De Bary Medal winner in Usher Hall.

It seems fitting that my last memory is of a beaming Franz receiving the De Bary Medal in Edinburgh in 2010. A true mycological giant has left us.

—Lorelei Norvell

Additional internet sources: https://species.wikimedia.org/wiki/Franz_Oberwinkler
www.uni-tuebingen.de/en/faculties/faculty-of-science/
IMA Fungus 1(1): 19–100 & 1(2): 15 [www.ingentaconnect.com/content/ima/imafung]
[Dr. Robert Bauer In Memoriam] https://link.springer.com/article/10.1007/s11557-015-1120-5

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A vulnerable thelephoroid fungus, *Lenzitopsis oxycedri*, on *Cupressus sempervirens* in Algeria

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Abstract—*Lenzitopsis oxycedri*, a white rot basidiomycete, is reported in Algeria for the first time, collected in the protected reserve of Zeralda, near Algiers, on living *Cupressus sempervirens*, a previously unrecorded host. More than 50 years after the original description of the species (from a Moroccan specimen), this is the second report from North Africa.

Key words—*Cupressaceae, Juniperus*, *Thelephorales*, southern Mediterranean, wood-decay fungus

Introduction

Lenzitopsis oxycedri was described by Malençon & Bertault (1963), based on a specimen collected on *Juniperus oxycedrus* L. from the Moroccan Rif in North Africa. The specimen was characterized by perennial, resupinate to effuse reflexed basidiocarps, a monomitic hyphal system, and globose to subglobose finely warted basidiospores, yellow to pale brown in KOH. This original description supported the segregation of *Lenzitopsis* Malençon & Bertault as a monotypic genus in *Thelephorales*.

Malençon & Bertault (1963), who described both macro- and microscopic characteristics of the species in detail, provided a Latin diagnosis. However,

Table 1. Published and herb. MA-fungi records of *Lenzitopsis oxycedri*

Year	Country	*Juniperus* sp.	Altitude (m)	Records	Reference
1963	Morocco	*J. oxycedrus*	900	1	Malençon & Bertault (1963)
1979–1980	Spain	*J. oxycedrus* *J. thurifera*	750–1050	3	García-Manjón & Moreno (1981)
1982	Morocco	*Juniperus* sp.	1360	1	Tellería (1984)
1986–2006	Spain	*J. oxycedrus* *J. thurifera* *J. phoenicea*	620–1460	22	herb. MA-Fungi
1991	Spain	*J. thurifera*	1050	1	Ryvarden (1991) – neotype
2000	Italy	*J. oxycedrus*	850	2	Bernicchia (2000)
2003	Turkey	*J. foetidissima*	1400	2	Doğan et al. (2007)
2005	Turkey	*J. foetidissima*	1100–1200	2	Doğan et al. (2011)
2010	Macedonia	*J. foetidissima*	1200	3	Karadelev et al. (2013)

because the holotype specimen on which their description was based had been lost, Ryvarden (1991) considered both genus and species as invalid, proposing instead *Lenzitella malenconii* Ryvarden as a gen. & sp. nov. [both mistakenly designated as "nom. nov."] and designating a Spanish specimen on *Juniperus thurifera* L. as holotype. This reassignment of names was later challenged by Stalpers (1993), who stated:

> "*Lenzitopsis* has been considered as invalidly published because no type species was indicated (Art. 37.1), and *L. oxycedri* because it was published in an invalidly published genus. However, *Lenzitopsis* was published with one species only, which was newly described and thus the description of *L. oxycedri* meets the conditions for a descriptio generico-specifico (Art. 42.1) and thus both genus and species are validly published."

Today, *Lenzitopsis oxycedri* is the accepted name, with *Lenzitella malenconii* regarded as a superfluous homotypic synonym, and Ryvarden's (1991) designation of a Spanish "holotype" and "isotype" is corrected to "neotype" and "isoneotype."

The records of *L. oxycedri,* summarized in Table 1, show that this species has been reported from only five countries in >50 years.

According to Malençon & Bertault (1963), *L. oxycedri* has small discrete basidiocarps, which make it easy to overlook. The authors reported the species

on *J. oxycedrus* at a single site in the Moroccan Rif; later examinations of *J. oxycedrus* and *J. thurifera* in the Rif and the Middle Atlas failed to find other occurrences (Malençon & Bertault 1963). *Lenzitopsis oxycedri* has been reported as either a saprobe or a parasite, exclusively on *Juniperus* spp. (Malençon & Bertault 1963; García-Manjón & Moreno 1981; Tellería 1984; Ryvarden 1991; Bernicchia 2000; Doğan & al. 2007, 2011; Karadelev & al. 2013). Here we report the first record of *L. oxycedri* in Algeria, growing on *Cupressus sempervirens* L. (Mediterranean cypress), a previously unknown host tree.

Materials & methods

Lenzitopsis oxycedri was collected in April 2017, in two different sites within the protected reserve of Zeralda, near Algiers, Algeria: (1) from *Cupressus sempervirens* ("*fastigiata*"), growing in a mixed stand of *Quercus ilex* L., *Quercus suber* L., and *Pistacia lentiscus* L.; (2) from *C. sempervirens* ("*fastigiata*" and "*horizontalis*") in a pure stand of Mediterranean cypress. Both sites are located around an artificial lake. Ecological data were noted, in both sites, for habitat description.

Identification was based on macro- and microscopic observations on fresh basidiomata, following the descriptions of Malençon & Bertault (1963), Ryvarden & Gilbertson (1993), Doğan & al. (2007), and Pérez Gorjón & Bernicchia (2008). Macromorphological characters were observed using a Leica S8AP0 stereomicroscope. Microscopic detailed analysis was performed using an Optika T3-I5A scientific microscope equipped with a Moticam-2000 camera. Basidiospores were examined in Melzer's reagent. Measurements were performed using Mycomètre free license software. The studied material is conserved at the University of Tartu Herbarium, Estonia (TU).

Taxonomy

Lenzitopsis oxycedri Malençon & Bertault,
Bull. Soc. Mycol. Fr. 79: 82 (1963) Figs 1–5

Type: Spain, Guadalajara, Tamajón, on living *Juniperus thurifera*, 26 Apr. 1991, leg, G. Moreno & L. Gonzaga (Neotype, ALC; isoneotype, O; designated by Ryvarden 1991).

= *Lenzitella malenconii* Ryvarden, Syn. Fung. 5: 174 (1991)

Basidiocarps lignicolous, perennial, adnate, resupinate to pileate, flexible when fresh, brittle and fragile when dry, 3–5 cm wide, and 5–7 mm thick. Pileal surface dark brown with a narrow clear margin, sub-zonate, glabrous and black when old; Hymenophore thick 3–10 mm, lamellate, lenzitoid, lamellae raduloid, incised, subulate or sinuous with toothed margin, at first yellowish, then ochraceous to brown with accumulated spores, cracked when old, sides with yellowish stromatic projections. Context whitish, corky, dry, soft, fragile, thin, covered with a spongy black cortex; Spore deposit brown.

Figs 1–4. *Lenzitopsis oxycedri* on *Cupressus sempervirens* (TU124571 & TU124572). 1. Pileate basidiocarps. 2. Resupinate basidiocarps. 3. Subzonate pileus. 4. Yellowish stromatic projections.

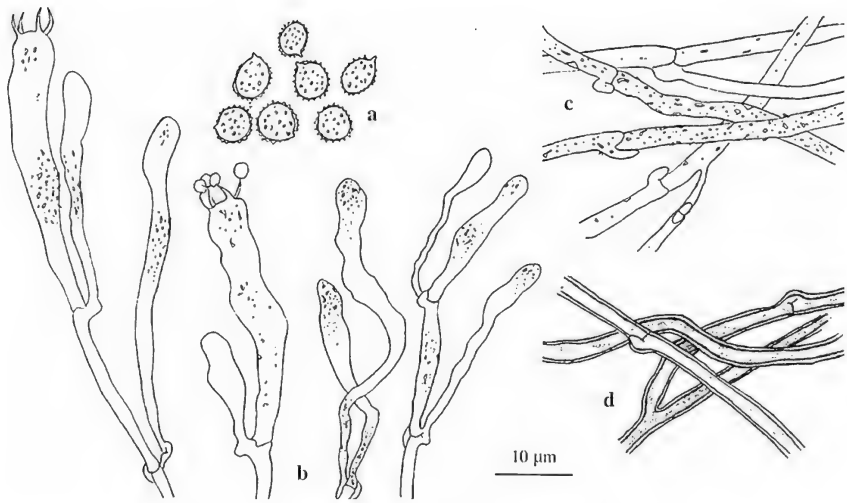

Fig. 5. *Lenzitopsis oxycedri* (TU124571 & TU124572).
a. Spores. b. Basidia and basidioles. c. Context generative hyphae. d. Pileus generative hyphae.

Hyphal system monomitic, generative hyphae fibrous, intersecting, pale brown in pileus, hyaline elsewhere, 2.5–5 µm diam, moderately branched, thin-walled, in age with brown crystals that turn to bluish-green in KOH. Cystidia absent; Basidia tetrasporic, clavate then elongate to sinuous, tube-like, 40–77 µm long, clamped at base; Basidiospores globose to subglobose, pale brown, thick-walled, finely warted, predominantly with small inamyloid inner pigment crystals, 5.7–7.5 × 4.6–7.5 µm.

Habitat—Growing >2 m above the ground on bark, branches, and cracks of living *Cupressus sempervirens*, at 49-80 m altitude, uncommon, known only from two sites within a protected reserve.

Specimens examined: **ALGERIA**, **Algiers**, **Protected Reserve of Zeralda**, growing at the base of branches of living *Cupressus sempervirens* ("*fastigiata*"), 4 Apr. 2017, leg. S. Aouali (TU124571); growing on trunks and branches of living *C. sempervirens* ("*fastigiata*" and "*horizontalis*"), 11 Apr. 2017, leg. S. Aouali (TU124572).

Comments—Dai & al. (2007) recorded four collections of *Lenzitella malenconii* [= *Lenzitopsis oxycedri*] from widely separated localities in China; however, these were subsequently described as a new species, *Lenzitopsis daii* L.W. Zhou & Kõljalg, which differs from *L. oxycedri* by its annual basidiocarps, amyloid spores, and LSU-rDNA sequence analyses placing it in a well-supported separate clade (Zhou & Kõljalg 2013). These authors stated that the position of

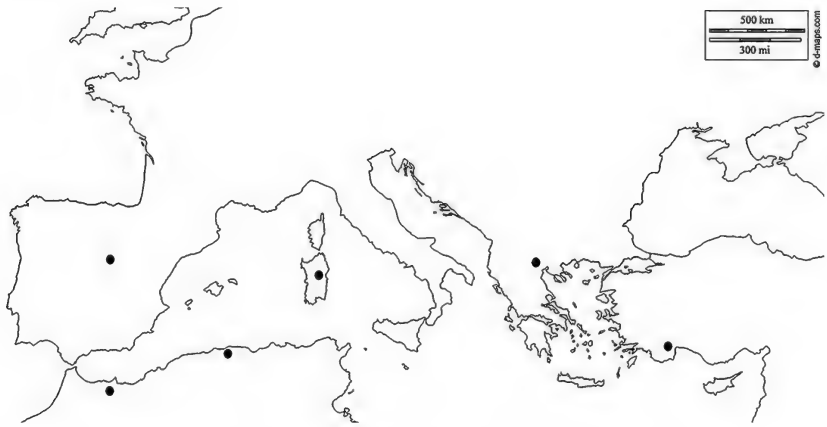

FIG. 6. Geographical distribution of *Lenzitopsis oxycedri* records.

Lenzitopsis is not yet resolved as either *Thelephoraceae* or *Bankeraceae*, the only two families currently accepted in *Thelephorales* (Kirk & al. 2008).

The geographical distribution of *L. oxycedri* (FIG. 6) is limited to the Mediterranean basin, particularly along the northern shore, from Spain, Italy, Macedonia and Turkey. This species has been reported to grow as a saprobe or parasite, and causing white rot on four *Juniperus* spp. (TABLE 1). Our report of this wood-decaying fungus in Algeria expands its distribution in the southern side of the Mediterranean, where it grows on living *Cupressus sempervirens*, at much lower altitudes (49–80 m) than all previous records (620–1460 m). This new host species suggests new perspectives for further mycological studies in areas characterized by the presence of other *Cupressaceae*, on which the fungus could potentially grow. Ecological data from the different habitats where *L. oxycedri* has been recorded should be compared, to clarify its chorology.

Acknowledgements

We would like to thank Leif Ryvarden and Alessandro Saitta for reviewing this article. We also thank Lei Cai for constructive comments on a previous draft of the manuscript. The authors gratefully thank the forestry staff of the Protected Reserve of Zeralda, for their help and for offering all logistical tools in conducting the field observations. L. Pecoraro acknowledges CAS 153211KYSB20160029 for supporting his research at Chinese Academy of Sciences.

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Arachnophora longa sp. nov., a freshwater hyphomycete from far north Queensland, Australia

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Abstract—*Arachnophora longa*, collected from submerged wood in far north Queensland, Australia, is described and illustrated as a new species. It is distinguished from other members of the genus by possessing macroconidia with long appendages ("arms").

Key words—anamorphic fungi, biodiversity, dematiaceous hyphomycete, lignicolous fungi, taxonomy

Introduction

During a survey of freshwater fungi on wood in streams in far north Queensland, a distinctive fungus was collected on submerged wood. The conidiogenesis and morphology of the conidia place this fungus in the genus *Arachnophora* Hennebert (Hennebert 1963). However, the fungus shows clear differences from previously described *Arachnophora* species and is therefore described as new to science.

Materials & methods

Samples of submerged wood less than 5 cm in diameter were collected from Oliver Creek, north Queensland, placed into sealed plastic bags, and returned to the laboratory. The collection site had a rocky base with shallow, running water and thick native riparian vegetation. Samples were then incubated in sterile plastic containers and regularly examined for fungi using a Leica MZ7s dissecting microscope. When noted, fungi were photographed, described, and transferred to a microscope slide with

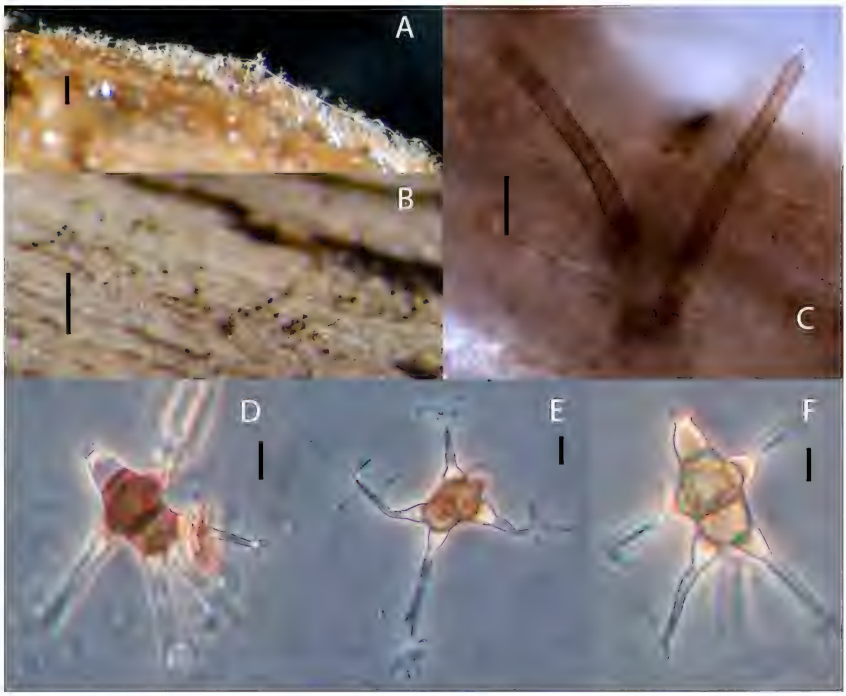

Fig. 1. *Arachnophora longa* (holotype, BRI AQ522463). A: Colonies on natural substrate while fresh. B: Colonies on natural substrate after drying. C: Conidiophores. D–F: Macroconidia with microconidial synanamorph. Scale bars: A, B = 200 µm; C–F = 10 µm.

a drop of distilled water and cover slip. This slide was examined using either a Leica DMLS compound microscope with phase contrast or a Nikon Eclipse Ni with difference interference contrast. Photographs were taken using either a Sony RX-100 or Lumenera Infinity 3 camera. Drawings were made with the assistance of a Nikon Y-IDT drawing tube at 100×.

Taxonomy

Arachnophora longa Fryar & K.D. Hyde, **sp. nov.** Figs 1, 2

MycoBank MB 823958

Differs from *Arachnophora combuensis* by its longer macroconidial arms and its slightly larger microconidia; and from *A. polyradiata* by its fewer but longer macroconidial arms.

Type: Australia, Queensland, Cape Tribulation, Oliver Creek, 16.137°S 145.440°E, on submerged wood, 7 Oct 2015, collector S. Fryar (**Holotype**, BRI AQ522463).

Etymology: Latin *longa,* referring to the relatively long macroconidial arms.

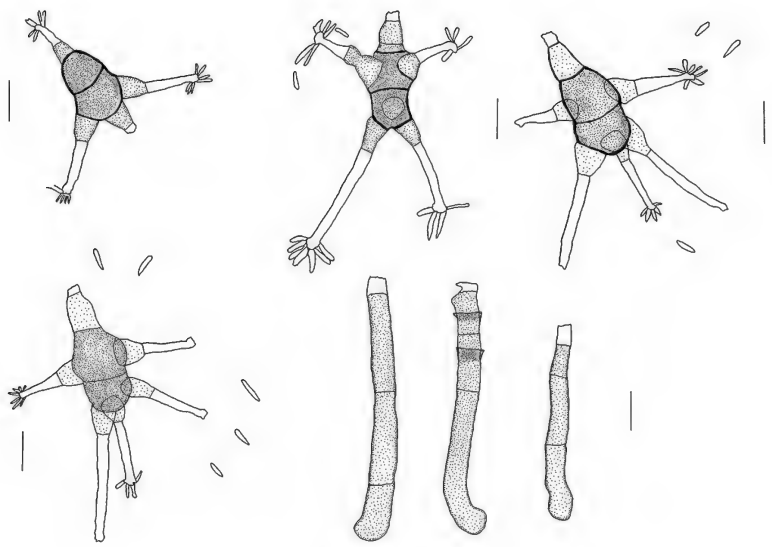

FIG. 2. *Arachnophora longa* (holotype, BRI AQ522463).
Conidiophores, macroconidia, and microconidia. Scale bars =10 μm.

CONIDIOPHORES macronematous, mononematous, brown, erect, unbranched, cylindrical, smooth, 1–4-septate, no constrictions at the septa, with percurrent proliferation, slightly bulbous at the base, single, 46–102 × 5–7.5 μm. CONIDIOGENOUS CELLS monoblastic, integrated, terminal, cylindrical, smooth, pale brown to hyaline. MACROCONIDIA staurosporous, acrogenous, solitary, brown, dry, smooth, complex, composed of [i] a basal cell that is obconical, truncate, pale brown, and with a minute basal frill as a result of rhexolytic dehiscence and [ii] an irregular two-celled central body of 17–23 × 11–19 μm; each central cell giving rise to 1–3 brown to pale brown lateral cells, 6–9 × 5–9 μm, each in turn giving rise to a single fertile, tapering, hyaline arm, 16–43 × 2–3 μm, usually aseptate (occasionally 1-septate), 3-5 arms per macroconidium. SYNANAMORPH: the apical cell of each macroconidial arm producing hyaline, aseptate, 5–10 × 1 μm, fusiform to clavate microconidia with minute denticles at their tip.

COMMENTS – *Arachnophora* was established by Hennebert (1963) for the type species, *A. fagicola,* growing on decaying cupules of *Fagus sylvatica.* Currently, there are ten species recognized in the genus. Of these species, *A. longa* most

resembles *A. polyradiata,* which differs by its longer (≤150 µm) conidiophores and more numerous (5-7) and shorter (15-20 µm) macroconidial arms (Mercado Sierra & Castañeda Ruíz 1984, Castañeda Ruíz & al. 1997). Three species—*A. fagicola*, *A. pulneyensis*, *A. uberisporoides*—do not produce a synanamorph (Hennebert 1963, Subramanian & Bhat 1987, Castañeda Ruiz & al. 1997) and are therefore distinct from *A. longa*. Macroconidia of *A. combuensis*, *A. crassa*, *A. dinghuensis*, *A. goanensis*, *A. hughesii*, and *A. polybrachiata* have fewer and shorter arms than *A. longa*, among other distinguishing characters (Révay & Gönczöl 1989, Castañeda Ruiz & Guarro 1999, Pratibha & al. 2011, Leão-Ferreira & al. 2013, Ma & al. 2014, Monteiro & al. 2014).

Arachnophora species are usually found on decaying leaves, wood, bark, or pods on forest floors (e.g., Kirk 1981, Matsushima 1993, Castañeda Ruiz & al. 1997, Pratibha & al. 2011, Ma & al. 2014). However, there have previously been reports of this genus on submerged wood in freshwater habitats (Tsui & al. 2000, Monteiro & al. 2014).

Acknowledgements

We would like to thank the Queensland Government for allowing us to collect samples. We also thank Dr Eric McKenzie and Dr Jian Ma for serving as presubmission reviewers and for providing helpful comments and suggestions.

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Graphis nudanorsticta sp. nov. and two new records of *Graphis* spp. from China

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Abstract—Three lichen species are reported from China: *Graphis nudanorsticta* is proposed as a new species, while *G. caribica* and *G. contortuplicata* represent new records for China.

Key words—*Ascomycota*, *Lecanoromycetes, Ostropales*, *Graphidaceae*, taxonomy

Introduction

Ninety species of the lichen genus *Graphis* Adans. have been reported from China (Wei 1991; Aptroot & Seaward 1999; Aptroot & Sipman 2001; Aptroot & Sparrius 2003; Seaward & Aptroot 2005; Joshi & al. 2015; Jia & Wei 2011, 2016; Jia & Lücking 2017a,b). In this paper, following the new genus concept (Staiger 2002; Lücking & al. 2009), we propose *Graphis nudanorsticta* as a new species and report *G. caribica* and *G. contortuplicata* as new records for China.

Materials & methods

Specimens were collected from Anhui and Guangxi Provinces, Southern China, and deposited in Lichen Herbarium of the College of Life Sciences, Liaocheng University, Shandong, China (LCU). Morphological and anatomical studies were conducted as described in Jia & Wei (2016).

Taxonomy

Graphis nudanorsticta Z.F. Jia & Q.D. Wang, **sp. nov.** Pl. 1

Fungal Name FN 570491

Differs from *Graphis pedunculata* by its smaller ascospores and corticolous thallus.

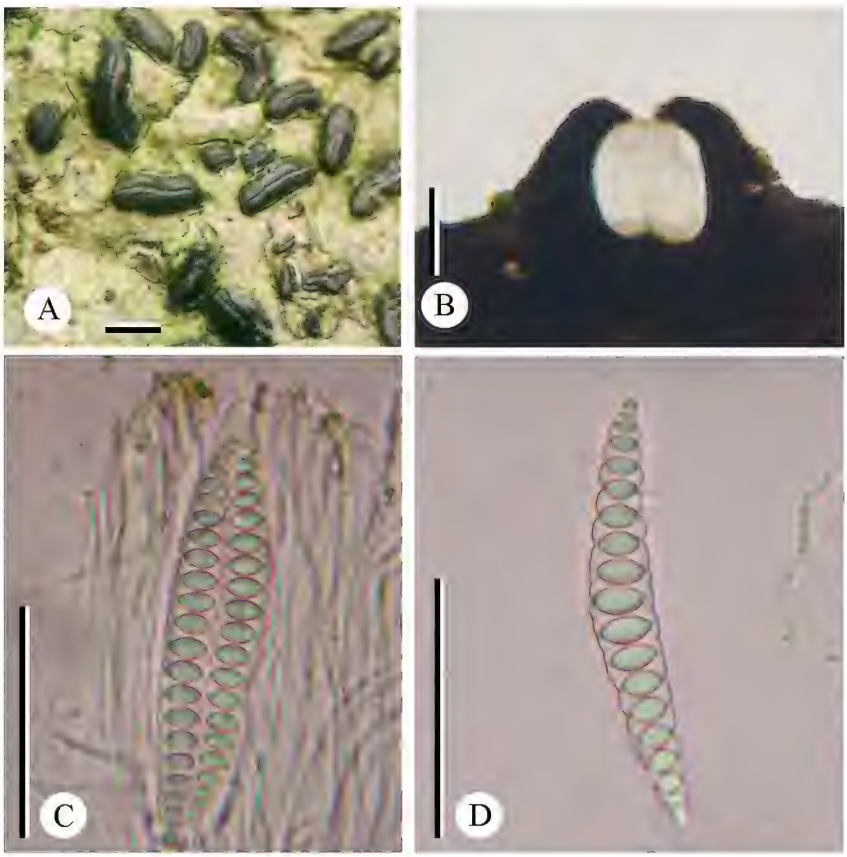

Plate 1. ***Graphis nudanorsticta*** (holotype, LCU: AH17106). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus containing ascospores; D. Ascospore. Scale bars: A = 1 mm; B = 100 μm; C, D = 50 μm.

Type: China. Anhui Province, Huangshan City, Mt. Huangshan, Yungu Temple, 30°07′N 118°10′E, alt. 1600 m, 18/VI/2017, Q.D. Wang AH17106 (**Holotype**, LCU).

Etymology: The epithet refers to the *nuda*-morph lirellae and the presence of norstictic acid.

Thallus crustose, yellow-green, rough, not smooth, tightly attached to the substratum, without isidia and soralia.

Apothecia lirelliform, short and unbranched, 0.5–3 mm long, 0.2–0.5 mm wide, black, scattered over the thallus, labia entire, disc concealed, lirellae prominent to sessile with basal thalline margin, *nuda*-morph; proper exciple conspicuous, completely carbonized; epithecium 15–25

µm tall, brownish; HYMENIUM hyaline, clear, 120–150 µm tall, paraphyses simple, 1–1.5 µm wide, slightly widened at apices; ASCI cylindrical to clavate, 80–110 × 15–35 µm, 2-spored; ASCOSPORES hyaline, ellipsoid, transversely septate, 16–22-locular at maturity, 65–100 × 8–15 µm, I+ violet, with halo and gelatinous caps.

CHEMISTRY: Norstictic acid (by TLC).

CORTICOLOUS.

ADDITIONAL SPECIMEN EXAMINED: **CHINA. ANHUI PROVINCE**, Huangshan City, Mt. Huangshan, Yungu Temple, 30°07′N 118°10′E, on bark, alt. 1250 m, 17/VI/2017, Q.D. Wang AH17022 (LCU).

REMARKS: *Graphis nudanorsticta* has similar morphology and chemistry to *G. pedunculata* Bungartz & Aptroot, which differs by having larger ascospores (130–210 × 22–27 µm) and preferring rock substrates (Lücking & al. 2009, Bungartz & al. 2010). The new species is also similar to *G. bifera* Zahlbr., which differs in the absence of norstictic acid. In the world key to *Graphis* (Lücking & al. 2009), *G. nudanorsticta* would key out at couplet 7, Group 8.

Graphis caribica Lücking, Phytotaxa 18: 59 (2011). PL. 2

THALLUS crustose, rough, yellow greenish, without isidia and soralia.

APOTHECIA lirelliform, elongate, conspicuous, black, simple or irregularly branched, 1–4 mm long, 0.3–0.5 mm wide, with basal thalline margin, labia striate (2–4), non-pruinose, *striatula*-morph; PROPER EXCIPLE apically carbonized; EPITHECIUM 10–20 µm tall, brownish; HYMENIUM hyaline, clear, 100–150 µm tall, paraphyses 1–1.5 µm diam, single, slightly inflated at apices; ASCI cylindrical to clavate, 90–105 × 15–25 µm, 8-spored; ASCOSPORES hyaline, ellipsoid, transversely septate, 10–16-locular, 40–65 × 6–9 µm, I+ violet, with thin halo.

CHEMISTRY: No lichen compounds detected by TLC.

CORTICOLOUS.

SPECIMENS EXAMINED: **CHINA. ANHUI PROVINCE**, Huangshan City, Mt. Huangshan, Banshan Temple, 30°07′N 118°10′E, alt. 1100 m, 18/VI/2017, Z.F. Jia AH17163, AH17164, AH17165 and AH17166 (all in LCU).

REMARKS: *Graphis caribica* is easily distinguishable from other striate labia species in China by its yellow-greenish thallus, clear hymenium, and transversely septate medium-sized ascospores. Prior to its formal description (Lumbsch & al. 2011), *G. caribica* was reported (as an unknown species) from Central America (Lücking & al. 2008, 2009).

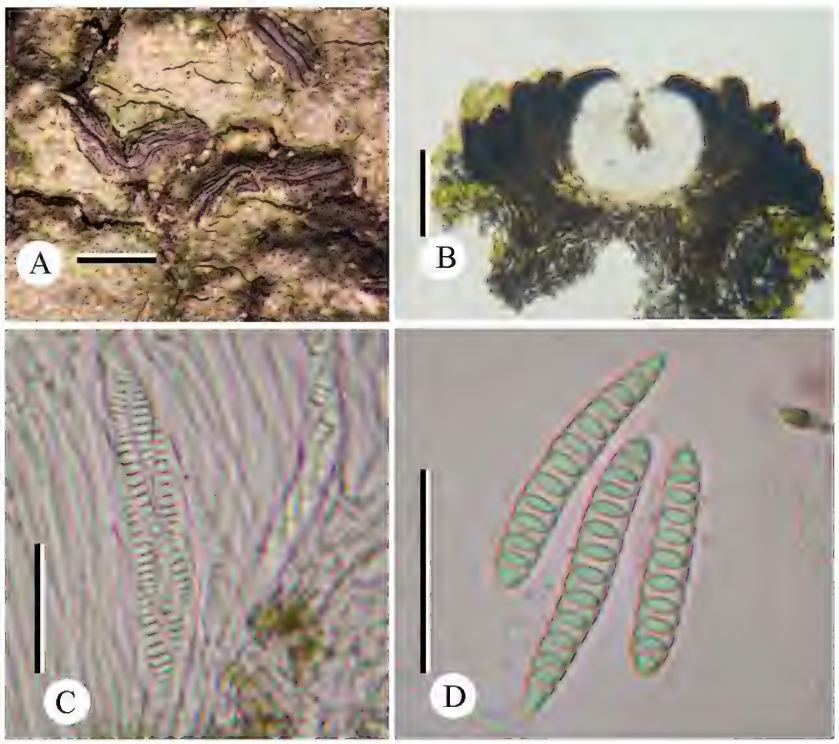

Plate 2. ***Graphis caribica*** (LCU: AH17163). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus containing ascospores; D. Ascospores. Scale bars: A = 1 mm; B = 100 μm; C = 50 μm; D = 30 μm.

Our Chinese materials appear identical to American material except for narrower ascospores (6–9 μm vs 9–12 μm diam).

Graphis contortuplicata Müll. Arg., J. Linn. Soc., Bot. 29: 225 (1892). Pl. 3

Thallus corticolous, crustose, greyish to pale grey, rough, not smooth, tightly attached to the substratum, without isidia and soralia.

Apothecia lirelliform, black, conspicuous, elongate, prominent to sessile, simple or rarely branched, 2–8 mm long, 0.2–0.3 mm wide, black, labia striate (2–4), non-pruinose, lirellae with basal thalline margin, *striatula*-morph; proper exciple completely carbonized; epithecium 15–25 μm tall, brownish; hymenium hyaline, clear, 110–140 μm tall, paraphyses 1.5–2.0 μm diam, single; asci cylindrical to clavate, 100–130 ×

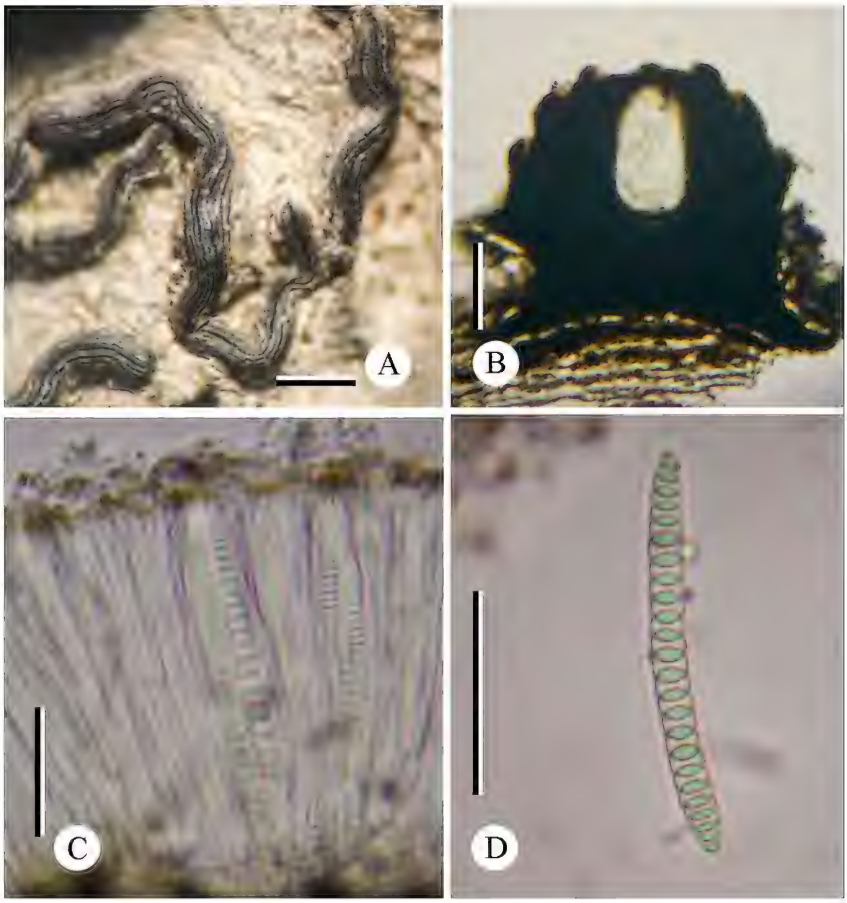

Plate 3. ***Graphis contortuplicata*** (LCU: GX15437-b). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus containing ascospores; D. Ascospore. Scale bars: A = 1 mm; B = 100 μm; C, D = 50 μm.

15–25 μm, 2–8-spored; ascospores hyaline, ellipsoid, transversely septate, halo, 20–24-locular at maturity, 80–120 × 7.5–9 μm, I+ violet, with halo and gelatinous caps.

Chemistry: no lichen compounds detected by TLC.

Corticolous.

Specimens examined: **CHINA. Guangxi Province**, Wuming County, Mt. Damingshan, Natural Medicine Bath Valley, 33°29′N 108°26′E, alt. 1240 m, 21/V/2015, J. Li GX15437-b (LCU); Mt. Damingshan, Aixin Lawn, 23°30′N 108°26′E, alt. 1250 m, 22/V/2015, J. Li GX15506 (LCU).

Remarks: *Graphis contortuplicata,* easily distinguished from other striate labiate species in China by its conspicuous black elongate lirellae, completely carbonized exciple, and larger ascospores, is similar to *G. granulata* Fée, which differs in producing shorter lirellae and 1–2-spored asci. Some specimens of *G. contortuplicata* from India are described with laterally carbonized exciples (Awasthi & Singh 1975, Awasthi 1991, Lücking & al. 2009). Our Chinese materials match almost exactly previous descriptions except for the 2–8-spored asci (vs 2–4 ascospores per ascus in previous descriptions).

Acknowledgements

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Notes on rust fungi in China 4. Hosts and distribution of *Hyalopsora aspidiotus* and *H. hakodatensis*

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Abstract—Hosts and distribution in China of two fern rust fungi, *Hyalopsora aspidiotus* and *H. hakodatensis,* are clarified based on new collections and examination of herbarium specimens. The ferns *Athyrium iseanum, Deparia orientalis,* and *Phegopteris connectilis* are newly identified hosts for *H. hakodatensis,* while *Gymnocarpium jessoense* represents a new host for *H. aspidiotus* in China. The rusts are also reported as new for several Chinese provinces.

Key words—*Pucciniomycetes,* taxonomy, *Uredinales*

Introduction

Rust fungi on ferns—species of *Hyalopsora, Milesina,* and *Uredinopsis* (together with anamorphic taxa designated as *Milesia*)—are distributed mainly in temperate to cold areas, especially where their alternate hosts (*Abies* species) are found (Cummins & Hiratsuka 2003). Many fern rust species are believed to occur in China because of the wide range of areas suitable for their growth. However, these rust fungi have been insufficiently investigated on the mainland. Tai (1979), who listed two *Hyalopsora,* six *Milesina,* and eight *Uredinopsis* species, recorded most of the sixteen species from Taiwan.

Hyalopsora is distinguished from the other two genera primarily by the hyaline walls and pigmented cytoplasm of its urediniospores and the

predominant production of amphispores (Cummins & Hiratsuka 2003). During an investigation of rust fungi in Jilin Province, northeast China, *Hyalopsora* species were found on two species of ferns growing in coniferous forests (*Abies nephrolepis*). These ferns have not been previously recorded as host plants of *Hyalopsora* species in China. After morphological comparisons with specimens borrowed from Fungarium, Institute of Microbiology Chinese Academy of Sciences (HMAS), the rusts were identified as *H. aspidiotus* and *H. hakodatensis*. Their host plants and distribution in China were also clarified based on fungarium specimens.

Materials & methods

The uredinial stages of rusts on two ferns, *Gymnocarpium jessoense* and *Deparia orientalis,* collected on Changbai Mt., Yanji City, Jilin Province, China. After morphological examination, the specimens were deposited in the Herbarium of Mycology, Engineering Research Center of Chinese Ministry of Education for Edible and Medicinal Fungi, Jilin Agricultural University, Changchun, China (HMJAU). *Hyalopsora* specimens were also borrowed for morphological comparisons from the Fungarium, Institute of Microbiology Chinese Academy of Sciences, Beijing, China (HMAS).

Morphological characters, including the size and shape of sori and spores, were examined using light microscopy (LM). Spores or thin-sections of sori were mounted in a drop of lactophenol solution on glass slides and examined and photographed using Zeiss AXIO imager equipped with differential interference contrast (DIC). Approximately 30 spores were randomly chosen from each specimen and the length, width, and wall thickness of spores were measured using Leica LAS X software attached to a Leica DM2000 microscope.

The surface features of spores were examined by scanning electron microscopy (SEM). For SEM, sori and spores obtained from dry specimens were attached to specimen holders by double-sided adhesive tape and coated with platinum-palladium using a Hitachi MC1000 Ion Sputter Coater and examined with a Hitachi SU8010 FE-SEM operated at 5–7 kV.

Results & discussion

Following morphological observations, the Jilin Province specimens were identified as *Hyalopsora aspidiotus* and *H. hakodatensis*. The following descriptions are based on Chinese specimens.

Hyalopsora aspidiotus (Peck) Magnus, Ber. Deutsch. Bot. Ges. 19: 582, 1901. Fig. 1

Spermogonial and aecial stages not found. Uredinia amphigenous but mostly hypophyllous, minute, subepidermal, at first covered by the epidermis and then erumpent, yellow to golden-yellow. Urediniospores oblong or ellipsoid,

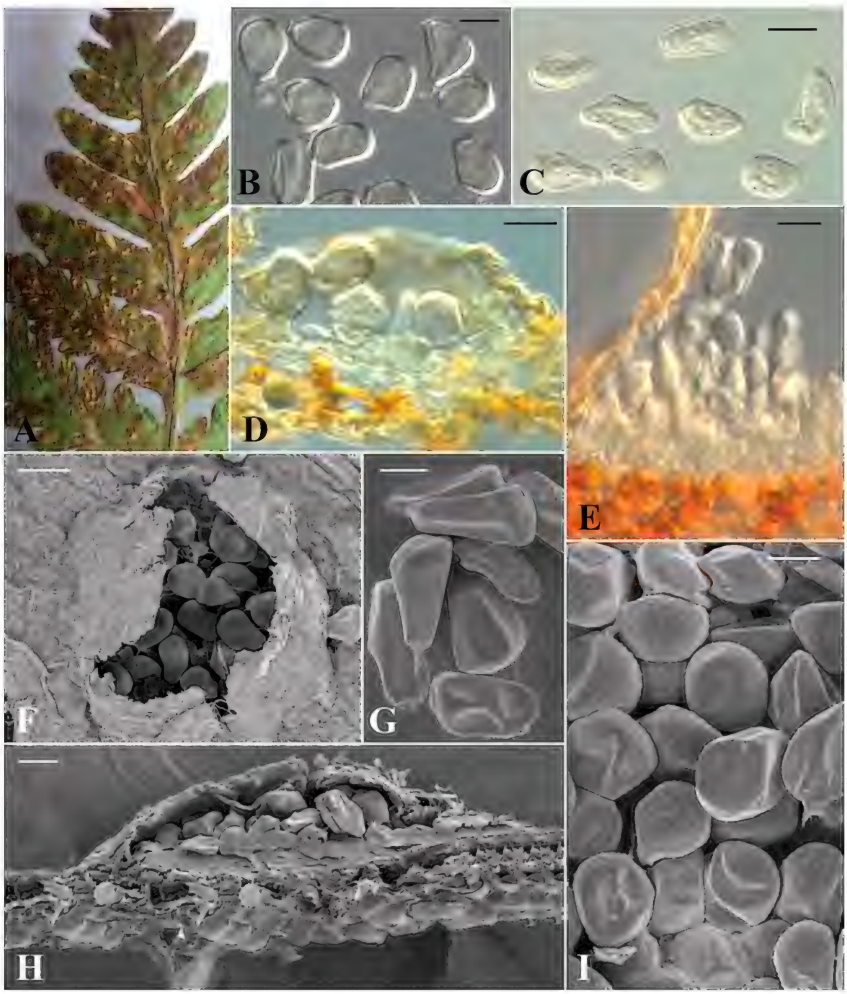

Fig. 1. *Hyalopsora aspidiotus*. A. Uredinia on lower leaf surface of *Gymnocarpium jessoense*. B. Amphispores on *G. jessoense*. C. Urediniospores on *G. disjunctum*. D. Vertical section of a sorus of amphispores on *G. jessoense*. E. Vertical section of a uredinium on *G. disjunctum*. F. Sorus of amphispores on the lower leaf surface of *G. jessoense* observed by SEM. G. Amphispores on *G. jessoense* by SEM. H. Vertical section of a uredinium on *G. disjunctum* by SEM. I. Urediniospores on *G. disjunctum* by SEM. Scale bars: B–F, H = 30 μm; G, I = 20 μm.

sometimes angular, 26.5–36 × 16.5–23 μm (av. 31.5 × 19.5 μm), walls thin, 1–1.5 μm, hyaline, smooth when observed under LM, but minutely verrucose under SEM. Amphispores abundant, subglobose, obovate, ellipsoid or oblong,

sometimes angular, 37.5–56.5 × 26–40.5 µm (av. 46.5 × 34.0 µm), walls thick, 4–8 µm, hyaline, smooth. Telia not found in specimens from China.

Specimens examined—**CHINA:**

Amphispores on ***Gymnocarpium jessoense*** (Koidz.) Koidz.: **Jilin Province**, Yanji, Changbai Mt., 42°24¢N 128°07¢E, alt. 1125 m, 22 August 014 (HMJAU8556); 22 September 2014 (HMJAU8555).

Urediniospores and amphispores on ***Gymnocarpium disjunctum*** (Rupr.) Ching: **Hebei Province**, Xiaowutaishan Mt., 24 August 1990 (HMAS67473). **Beijing Municipality**, Tiansishan Mt., 17 August 1957 (HMSA55065); 22 June 1956 (HMAS55064); Baihuashan Mt., 7 June 1957 (HMAS55063); 25 June 1964 (HMAS55078).

Amphispores on ***Phegopteris connectilis*** (Michx.) Watt: **Jilin Province**, Yanji, Changbai Mt., August 1991 (HMAS67289).

Hosts & distribution in China—*Gymnocarpium jessoense* (new host for China), Jilin Province; *G. disjunctum* (new host), Hebei Province, Beijing Municipality; *Phegopteris connectilis* [= *P. polypodioides*, *Doryopteris phegopteris*] (Xue & al. 1997) Jilin Province, Heilongjiang Province.

Although urediniospores and teliospores were not found, we identified the new specimens on *G. jessoense* as *H. aspidiotus* because the amphispores were morphologically identical with those described by Hiratsuka (1936), Hiratsuka & al. (1992), and Azbukina (2015). *Gymnocarpium jessoense* has been recorded as a host plant for this rust from Russian Far East (Azbukina 2015), but not previously reported from China. *Hyalopsora aspidiotus* is widespread and commonly found in Europe, North America, Russia, Korea, and Japan on *Gymnocarpium* species (Ito 1938, Hiratsuka 1958, Uchida 1964, Hiratsuka & al. 1992, Azbukina 2015, Termorshuizen & Swertz 2011). In China this rust has previously been recorded only on *Phegopteris connectilis* from Heilongjiang Province in northern China (Xue & al. 1997).

We also examined specimens deposited as *H. aspidiotus* in HMSA to confirm our identification, which also revealed *G. disjunctum* as a new host plant for *H. aspidiotus* and the rust's wider distribution in China (Beijing, Hebei, Jilin, Heilongjiang). Spermogonial and aecial stages of *H. aspidiotus,* known on *Abies* species in Europe and North America, have never been reported in Asia (Hiratsuka 1958).

Hyalopsora hakodatensis Hirats. f.,
Trans. Tottori Soc. Agric. Sci. 4(1): 20, 25. 1932. Fig. 2

Uredinia amphigenous, minute, subepidermal, orange to orange-yellow. Urediniospores ellipsoid, oblong or clavate, sometimes angular, 16.5–26.5 × 12.5–16.5 µm (av. 22.5 × 14.5 µm), walls thin, 0.5–1 µm, hyaline, smooth

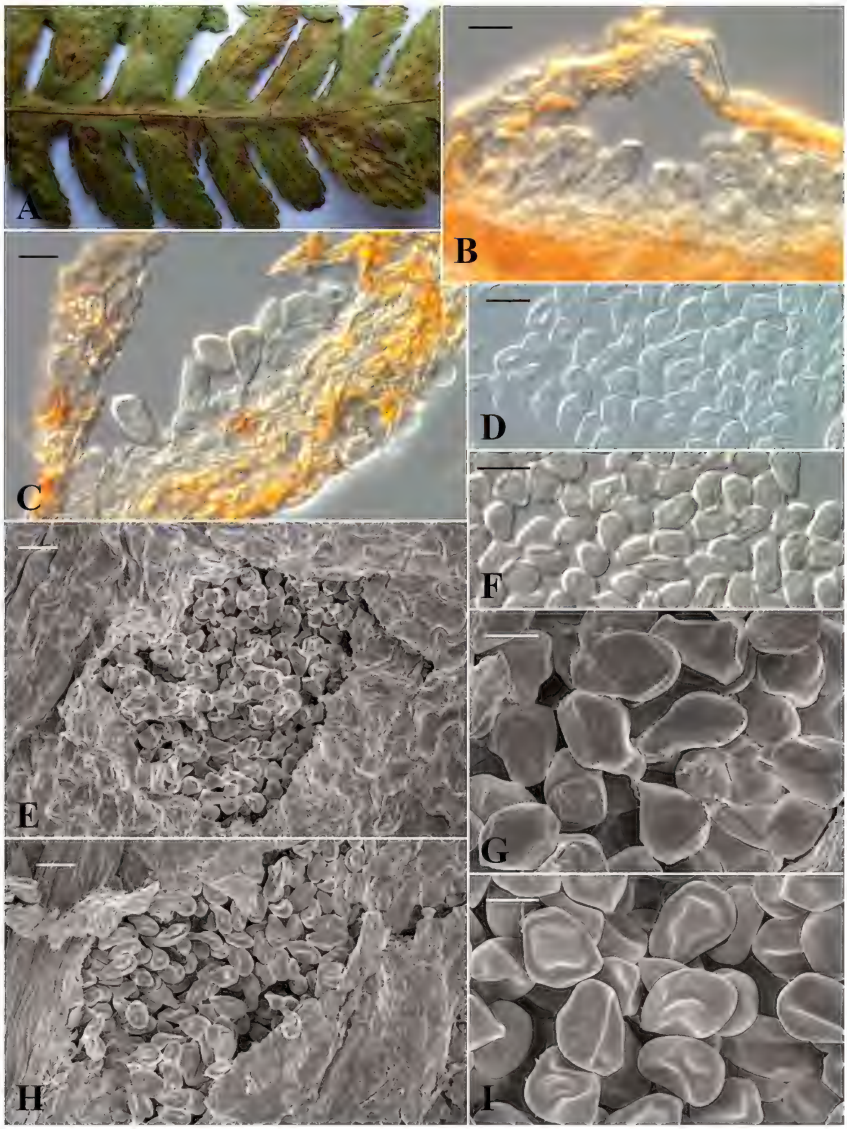

Fig. 2. *Hyalopsora hakodatensis.* A. Uredinia on lower leaf surface of *Deparia orientalis*. B. Vertical section of a uredinium on *D. orientalis*. C. Vertical section of a sorus of amphispores on *Lunathyrium* sp. D. Urediniospores on *D. orientalis*. E. Uredinium on the lower leaf surface of *D. orientalis* observed by SEM. F. Amphispores on *Lunathyrium* sp. G. Urediniospores on *D. orientalis* by SEM. H. Sorus of amphispores on *Athyrium* sp. by SEM. I. Amphispores on *Athyrium* sp. by SEM. Scale bars: B–F, H = 30 μm; G, I = 25 μm.

when observed under LM, but minutely verrucose when observed by SEM. Amphispores obovate, pyriform or oblong, sometimes angular, 20–31.5 × 15.5–21 µm (av. 25.5 × 17.5 µm), walls thick, 1.5–4 µm, hyaline, smooth. Telia not found.

Specimens examined—**CHINA:**

Urediniospores and amphispores on ***Deparia orientalis*** (Z.R. Wang & J.J. Chien) Nakaike: **Jilin Province**, Yanji, Changbai Mt., 42°13¢N 128°12¢E, alt. 1035 m, 23 September 2015 (HMJAU8557).

Urediniospores and amphispores on ***Dryopteris* sp.: Yunnan Province**, Kunming, Xishan, December 1938 (HMAS11209)

Urediniospores and amphispores on ***Phegopteris decursive-pinnata*** (H.C. Hall) Fée: **Fujian Province**, Jianyang, 18 September 1980 (HMAS41581).

Amphispores on ***Athyrium iseanum*** Rosenst.: **Yunnan Province**, Kunming, 19 October 1985 (HMAS50158).

Urediniospores and amphispores on ***Arthyrium* sp.: Tibet**, Nyalam, 10 October 1990 (HMAS79173).

Urediniospores and amphispores on ***Lunathyrium* sp.: Hainan Province**, Bawangling, 29 March 1993 (HMAS 77886).

Hosts & distribution in China—*Athyrium iseanum* [= *A. dissectifolium*] (new host), Yunnan Province; *Athyrium* sp., Tibet; *Deparia orientalis* [= *D. albosquamata*] (new host), Jilin Province; *Dryopteris* sp. (Tai 1979), Yunnan Province; *Lunathyrium* sp., Hainan Province; *Phegopteris decursive-pinnata* (new host), Fujian Province.

We identified the specimen on *D. orientalis* as *H. hakodatensis* based on its small amphispores and urediniospore characteristics that were identical with those described by Hiratsuka & Uemura (1932), Hiratsuka (1936), Hiratsuka & al. (1992), and Azbukina (2015). *Hyalopsora hakodatensis* has been reported on species of *Athyrium, Diplazium*, and *Thelypteris* from Japan, Taiwan, Korea, Russian Far East, and Nepal (Hiratsuka 1958, Uchida 1964, Hiratsuka & al. 1992, Azbukina 2015). *Deparia orientalis* is a new host plant for this rust fungus. Previously, the presence of *H. hakodatensis* in China was based solely on one specimen on *Dryopteris* sp. from Yunnan Province (Tai 1979).

Our examination of specimens deposited as *H. hakodatensis* in HMAS morphologically confirmed our identification and revealed *Athyrium iseanum* and *Phegopteris decursive-pinnata* as new host plants for *H. hakodatensis* and clarified the rust's distribution in China (Yunnan, Hainan, Fujian, Jilin, Tibet). *Hyalopsora hakodatensis,* suspected to have a wide range of fern hosts, is widely distributed in China. Spermogonial and aecial stages have not been reported, although they may be produced on species of *Abies* (Hiratsuka & al. 1992, Azbukina 2015).

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Rosellinia jiangxiensis and *R. yunnanensis* spp. nov. and a new *Rosellinia* record from China

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Abstract—Two new species, *Rosellinia jiangxiensis* and *R. yunnanensis*, are proposed for specimens collected in China, and *R. leopoldensis* is recorded as new to China.

Key words—*Ascomycota*, pyrenomycetous fungi, taxonomy, *Xylariaceae*

Introduction

Mycological investigations dealing with two new *Rosellinia* species from Southern China were published by Li & Guo (2015, 2016). Two additional new species of *Rosellinia*, collected in Jiangxi and Yunnan Provinces, are described here, and *R. leopoldensis* is reported as a new record for China. These specimens are conserved in Herbarium Mycologicum Academiae Sinicae, Beijing, China (HMAS).

Materials & methods

The specimens were examined using a Motic SMZ-168 stereomicroscope. Microscopic features of asci and ascospores were described from slide preparations mounted in water and Melzer's reagent, and measurements were made from 20 ascospores, using a Zeiss Axioskop 2 plus compound microscope. Stromata were photographed using a Sony NEX-7 digital camera.

Taxonomy

Rosellinia jiangxiensis Wei Li bis & L. Guo, **sp. nov.** Figs 1–3

Fungal Name FN 570498

Differs from *Rosellinia gisbornia* by its broader ascospores and larger ascus apical ring.

Type: China, Jiangxi, Nanchang, Meiling, alt. 200 m, on twig, 28.X.2016, L. Guo 11971 (**Holotype**, HMAS 255161).

Etymology: The epithet refers to the type locality, Jiangxi Province.

Subiculum dark brown, evanescent. Stromata solitary to gregarious, subglobose to cupulate, dark brown to black, 800–875 × 650–800 µm. Ostioles papillate, black. Ectostroma 50–100 µm thick, black. Entostroma disappearing in old stage. Perithecia globose or subglobose (620–750 × 380–500 µm). Ascus apical ring bluing in Melzer's iodine reagent, 9–14 µm tall, diameters 4–5 µm above, 4–6 µm below. Ascospores asymmetrically ellipsoidal, usually with broadly to narrowly rounded ends (sometimes pinched at one end), completely surrounded by a slimy sheath thicker at both ends, 25–31 × 7–11 µm, brown, with straight germ slit extending the length of the spore.

Comments: *Rosellinia jiangxiensis* is similar to *R. gisbornia* L.E. Petrini, which differs in its cream-coloured to light brown subiculum, thinner (50-75 µm) ectostroma, narrower (6.7–8.6 µm) ascospores, and ascus apical rings that are shorter (4.8–8.6 µm) and narrower (2.8–4.8 µm above, 2.8–3.8 µm below (Petrini 2003, 2013b).

Rosellinia yunnanensis Wei Li bis & L. Guo, **sp. nov.** Figs 4–6

Fungal Name FN 570499

Differs from *Rosellinia leopoldensis* by its taller ascus apical ring; and from *R. caudata* by its ascospores lacking a cellular appendage.

Type: China, Yunnan, Puer, alt. 1470 m, on unidentified wood, 17.III.2017, L. Guo 12190 (**Holotype**, HMAS 255162).

Etymology: The epithet refers to the type locality, Yunnan Province.

Subiculum well developed, woolly, felted or interlaced, dark brown, retained at maturity. Stromata solitary to densely gregarious, subglobose, brown, 750–1000 µm × 800–1000 µm, with the bases embedded in the subiculum. Ostioles papillate, black. Ectostroma 150–200 µm thick, black. Entostroma disappearing at maturity. Perithecia subglobose, 500–600 × 600–700 µm. Ascus apical ring bluing in Melzer's iodine reagent, 10–15 µm high, diameter 5–6 µm above, 5–6.5 µm below. Ascospores asymmetrically ellipsoidal, with broadly to narrowly rounded ends, surrounded completely by a slimy sheath

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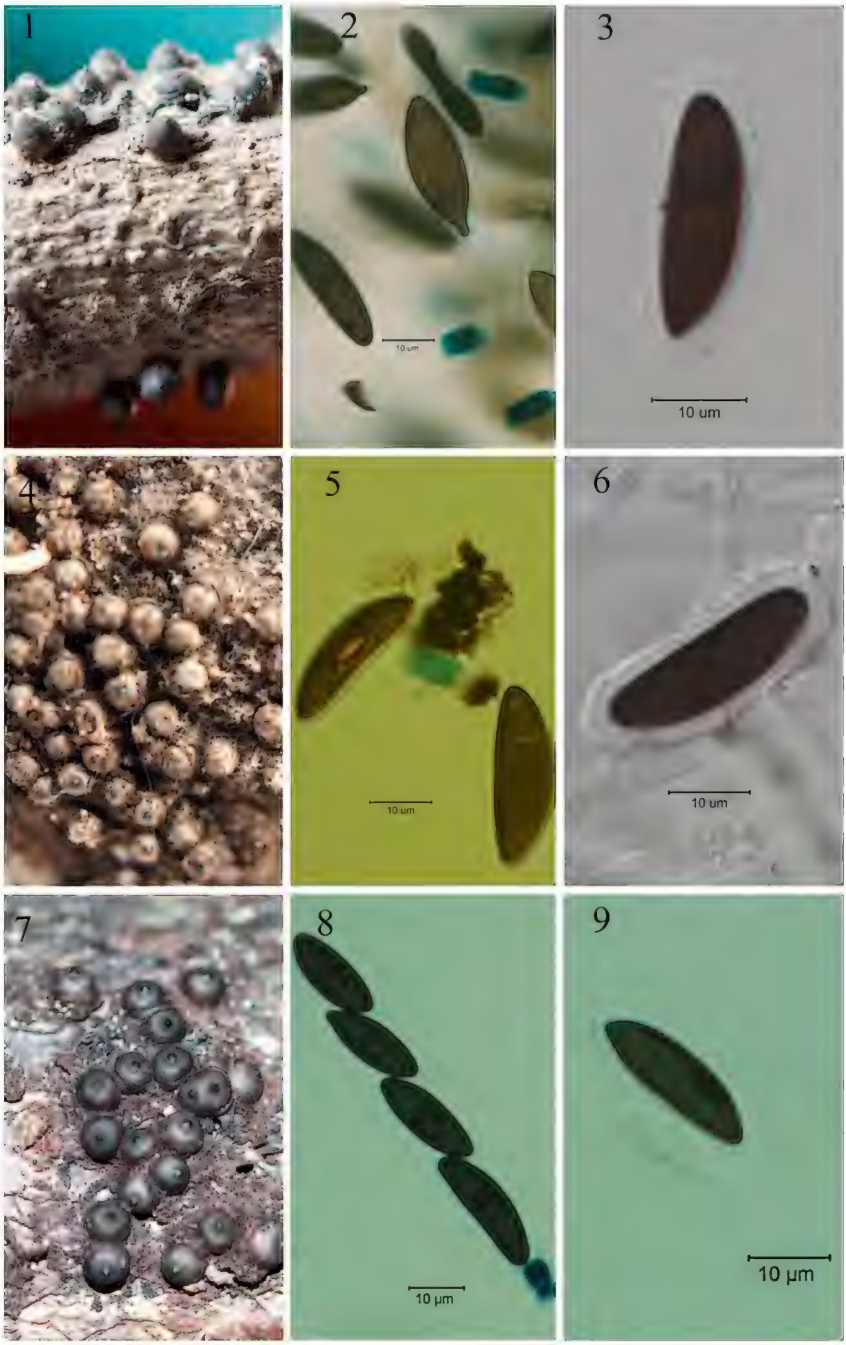
Figs 1–9. ***Rosellinia jiangxiensis*** (HMAS 255161, holotype). 1. Stromata on twig; 2. Ascospores and ascus apical rings; 3. Ascospore. ***Rosellinia yunnanensis*** (HMAS 255162, holotype). 4. Stromata on wood; 5. Ascospores and ascus apical ring; 6. Ascospore. ***Rosellinia leopoldensis*** (HMAS 245738). 7. Stromata on wood; 8. Ascus and ascospores; 9. Ascospore.


1
2
10 um
3
10 um
4
5
10 um
6
10 um
7
8
10 µm
9
10 µm

that is thicker at ends, 21–31 × 5.5–10 μm, brown, with straight germ slit extending the length of the spore.

Comments: *Rosellinia yunnanensis* is similar to *R. leopoldensis*, which differs in its shorter (7–8 μm) ascus apical ring (Petrini 2013a,b). *Rosellinia caudata* Petch differs from *R. yunnanensis* by its ascospores having a cellular appendage at one end (Petrini 2013b).

Rosellinia leopoldensis L.E. Petrini, Index Fungorum 25: 3, 2013. Figs 7–9

Subiculum well developed, woolly, felted or interlaced, dark brown, retained at maturity. Stromata often densely gregarious, sometimes solitary, covered with basic subiculum, subglobose but laterally squashed, 900–1100 × 800–1200 μm, brown. Ostioles papillate, black. Ectostroma 60–100 μm thick, black. Entostroma disappearing at maturity. Perithecia subglobose, 700–800 μm high, 800–900 μm diam. Ascus apical ring dark bluing in Melzer's iodine reagent, 7–8 μm tall, diameter 3–4.5 μm above, 3.5–5 μm below. Ascospores asymmetrically ellipsoidal, with rounded or pinched ends, surrounded by a slimy sheath being thicker at ends, 18–25 × 6–10 μm, dark brown, with straight germ slit extending the length of the spore.

Specimens examined: **CHINA**, **Heilongjiang**, **Yichun**, Wuying National Forest Park, alt. 430 m, on corticated wood, 26.VIII.2014, W. Li 14104 (HMAS 245738); W. Li 14105 (HMAS 245741).

Comments: The collection from Wuying National Forest Park represents a new record for China. Our specimens are morphologically similar to the holotype, but their ascus apical rings were slightly taller than those of the holotype (5.5–7 μm; Petrini 2013a).

Discussion

Including the three species reported in this paper, we now recognize 41 *Rosellinia* species in China (Teng 1963, Tai 1979, Ju & Rogers 1990, 1999; Yuan & Zhao 1993, Lu & al. 2000, Liu & al. 2010, Petrini 2013a,b; Li & Guo 2015, 2016; Li & al. 2015, Su & al. 2016).

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Distribution of *Alternaria* species among sections. 4. Species formerly assigned to genus *Nimbya*

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Abstract—Morphological examination of phylogenetically unexamined species of the superseded genus *Nimbya* have permitted the inclusion of additional species in *Alternaria* sect. *Nimbya* (two species from monocots), *A.* sect. *Alternantherae* (two species from *Amaranthaceae*), and *A.* sect. *Porri* (one species from *Asteraceae*). Four other *Nimbya* species should be considered as taxa that are not distinguishable as unique within *A.* sect. *Alternaria*. *Alternaria* sect. *Alternantherae* now includes six species, *A.* sect. *Nimbya* includes six species, and *A.* sect. *Porri* consists of 118 morphospecies. To bring their nomenclature into accordance with modern *Alternaria* taxonomy, five new combinations and two replacement names are proposed for seven species previously accommodated in *Nimbya*.

Key words—*Alternaria crassoides*, *A. heteroschemos*, *A. juncicola*, *A. pimpriana*, *A. rhapontici*

Introduction

Alternaria Nees is a large, morphologically diverse genus that comprises approximately 280 distinguishable morphospecies (Simmons 2007). Recently, several series of morphological and phylogenetic studies have attempted to refine the phylogeny of *Alternaria* and other alternarioid hyphomycetes by utilizing more than ten different loci (Pryor & Bigelow 2003; Hong & al. 2005; Runa & al. 2009; Lawrence & al. 2012, 2013, 2014; Woudenberg & al. 2013, 2014; Armitage & al. 2015). Many well-supported lineages (phylogenetic species-groups) have been realized within the alternarioid hyphomycetes and have led to several taxonomic novelties. The genus *Alternaria* was recently divided into eight taxonomic sections by Lawrence & al. (2013) followed by the elevation of

19 additional clades by Woudenberg & al. (2013, 2014), Grum-Grzhimaylo & al. (2016), and Lawrence & al. (2016), bringing the total number of *Alternaria* sections to 27. Therefore, all former alternarioid hyphomycetes (13 genera) were transferred to *Alternaria*, including the type species of the genus *Nimbya*.

Nimbya was described by E.G. Simmons to cluster species characterized by specific septation and polygonal lumina in conidial transverse sections. In total, 17 *Nimbya* species have been proposed (Simmons 1989, 1995, 1997, 2000, 2004; Chen & al. 1997; Johnson & al. 2002; Zhao & Zhang 2005), of which 14 were established by E.G. Simmons: six species on *Amaranthaceae*, six species on monocots (*Cyperaceae*, *Juncaceae*), one species on *Asteraceae*, and one species on *Solanaceae*. The other three species were found on *Fabaceae*, *Caryophyllaceae*, and *Euphorbiaceae*.

A molecular phylogenetic study by Lawrence & al. (2012) revealed *Nimbya* as polyphyletic, with one group nested in *Alternaria* and the other closely related to *Embellisia* species. To resolve the polyphyly of *Nimbya*, Lawrence & al. (2012) divided *Nimbya* into the alternantherae species-group (strongly supported as sister to the alternata species-group) and *Nimbya* proper, which also correlated with plant hosts and morphological conidial characters. After all alternarioid hyphomycetes were collected under the single name *Alternaria*, four species (including the type of *Nimbya*, *N. scirpicola*) were placed in *Alternaria* sect. *Nimbya* (hosts from *Cyperaceae: Scirpus*, *Eleocharis*, and *Carex*) and four species were placed in *A.* sect. *Alternantherae* (hosts from *Amaranthaceae: Alternanthera*, *Celosia*, and *Gomphrena*).

These two sections are distinguished by several morphological characters (Lawrence & al. 2012, 2013, 2016; Woudenberg & al. 2013). Conidia in *A.* sect. *Alternantherae* are solitary or rarely paired; usually with long and filiform beaks; and in transverse sections lumina are distinctly delimited and hexagonal, octagonal, or rounded. Conidia in *A.* sect. *Nimbya* are solitary or in short chains of 2–8 units; rarely longitudinally septate; with extended and cone-shaped apical beaks; and in transverse sections lumina are rectangular, hexagonal, or encompass the entire volume. Some *A.* sect. *Nimbya* species have a known sexual state (formerly called *Macrospora*), which is morphologically similar to, but distinct from, other *Alternaria* teleomorphs, including those formerly called *Lewia* and *Allewia* (Lawrence & al. 2016).

Nine species of the former genus *Nimbya* are considered incertae sedis. The aim of this work was to examine the morphology of phylogenetically unexamined *Nimbya* species to determine their affiliation with any *Alternaria* sections. This work is a continuation of the series started with the manuscripts

on *Alternaria* sections *Porri*, *Alternaria*, *Infectoriae*, and *Pseudoalternaria* (Gannibal 2015, 2016; Gannibal & Lawrence 2016).

Materials & methods

The morphology of all *Nimbya* species was analyzed with regard to conformity with criteria of *Alternaria* sections. The morphological assessment was based on descriptions made by Simmons (1989, 1995, 1997, 2000), Chen & al. (1997), and Zhao & Zhang (2005).

Results & discussion

The *Alternaria* sectional affiliations of all 17 species formerly assigned to *Nimbya* are listed in Table 1. Evaluation of descriptions of nine *Nimbya* species allowed for their placement in *Alternaria*: two species from *Amaranthaceae* (*A. crassoides* from *Froelichia* and *A. pimpriana* from *Celosia*) were placed in *A.* sect. *Alternantherae;* two species from monocots (*A. heteroschemos* from *Carex* and *A. juncicola* from *Juncus*) should be considered members of *A.* sect. *Nimbya;* and species from other hosts were placed in *A.* sect. *Porri* (one species) and *A.* sect. *Alternaria* (four species).

Separation of cellular contents and formation of specific polygonal lumina in transverse conidial sections was found in many *Alternaria* species. Slight or distinct cellular content separation was fixed in Simmons's drawings (1997, 2000) for small-spored [≈ *A.* sect. *Alternaria*] and large-spored species [≈ *A.* sect. *Porri*]. We also observed this feature in many old herbarium specimens of different *Alternaria* species during other studies. Thus this feature is not unique for sections *Alternantherae* and *Nimbya*.

Nimbya rhapontici from *Asteraceae* has a relatively large conidial body and long filiform branched beak that is a characteristic feature of several *A.* sect. *Porri* species (Gannibal 2015; Lawrence & al. 2016).

Nimbya dianthi, *N. dolichi*, *N. euphorbiicola*, and *N. major* morphology fit the *A.* sect. *Alternaria* description (Gannibal 2016), but they have somewhat longer (≤67 µm) conidial bodies. All four species were described from herbarium specimens. Simmons (1995) observed that in the field small-spored *Alternaria* species produce conidia that are noticeably larger and differently shaped compared to conidia produced in culture.

Simmons (2007) described most *Alternaria* species using cultures grown under standardized conditions. There is no actual possibility to make appropriate comparisons of herbarium specimens with *A.* sect. *Alternaria* species described from artificial culture media. Moreover, morphology in *A.* sect. *Alternaria* sufficiently contradicts phylogeny (Peever & al. 2004,

2005; Andrew et al 2009). Many species were synonymized based on molecular data (Woudenberg & al. 2015). Therefore, *Nimbya dianthi*, *N. dolichi*, *N. euphorbiicola*, and *N. major* should be considered taxa that are not distinguishable as unique within *A.* sect. *Alternaria*.

To bring nomenclature in accordance with modern-day *Alternaria* taxonomy I propose the five new combinations and two replacement names listed below. As a result of this study *A.* sections *Alternantherae* and *Nimbya* now include six species each, while *A.* sect. *Porri* (Gannibal 2015) now includes 118 morphospecies.

Taxonomy

Alternaria crassoides (Davis) Gannibal, **comb. nov.**

MycoBank 822404

≡ *Cercospora crassoides* Davis, Trans. Wisconsin Acad. Sci. 21: 298 (1924)

≡ *Nimbya crassoides* (Davis) E.G. Simmons, Mycotaxon 55: 146 (1995)

Alternaria dolichi (T.Y. Zhang & G.Z. Zhao) Gannibal, **comb. nov.**

MycoBank 822503

≡ *Nimbya dolichi* T.Y. Zhang & G.Z. Zhao, Fungal Diversity 19: 207 (2005)

Alternaria heteroschemos (Fautrey) Gannibal, **comb. nov.**

MycoBank 822405

≡ *Macrosporium heteroschemon* Fautrey, Rev. Myco. (Toulouse) 18: 69 (1896)

≡ *Nimbya heteroschemos* (Fautrey) E.G. Simmons, Sydowia 41: 323 (1989)

Alternaria juncicola (E.G. Simmons) Gannibal, **comb. nov.**

MycoBank 822407

≡ *Nimbya juncicola* E.G. Simmons, Sydowia 41: 321 (1989)

Alternaria nimbyae-dianthi Gannibal, **nom. nov.**

MycoBank 822505

≡ *Nimbya dianthi* T.Y. Zhang & G.Z. Zhao, Fungal Diversity 19: 207 (2005)

Etymology: *nimbyae-dianthi* refers to the basionym, *Nimbya dianthi*.

Alternaria nimbyoides Gannibal, **nom. nov.**

MycoBank 822504

≡ *Nimbya euphorbiicola* W.Q. Chen & T.Y. Zhang, Mycosystema 16: 106 (1997)

Etymology: *nimbyoides* means similar to *Nimbya*.

Alternaria rhapontici (Nelen) Gannibal, **comb. nov.**

MycoBank 822406

≡ *Macrosporium rhapontici* Nelen, Bot. Mater. Otd. Sporov. Rast. Bot. Inst. Komarova Akad. Nauk S.S.S.R.15: 146 (1962)

≡ *Nimbya rhapontici* (Nelen) E.G. Simmons, Mycotaxon 65: 21 (1997)

TABLE 1. Homotypic *Alternaria* synonyms of *Nimbya* species, now assigned to *Alternaria* sections *Alternantherae*, *Alternaria*, *Nimbya*, and *Porri*.

References providing phylogenetic data shown in parentheses.
Unannotated names = species with reliable living cultures and herbarium specimens.
Bold font = species not previously assigned to any *Alternaria* section.
Asterisks = species for which no known living isolates are available.

Alternaria sect. *Alternantherae*

A. alternantherae Holcomb & Antonop.
(Lawrence & al. 2012, 2013; Woudenberg & al. 2013)
≡ *N. alternantherae* (Holcomb & Antonop.) E.G. Simmons & Alcorn

A. celosiicola Jun. Nishikawa & C. Nakash.
(Lawrence & al. 2012, 2013)
≡ *N. celosiae* E.G. Simmons & Holcomb

A. crassoides (Davis) Gannibal [*]
≡ *N. crassoides* (Davis) E.G. Simmons

A. gomphrenae Togashi
(Woudenberg & al. 2013)
≡ *N. gomphrenae* (Togashi) E.G. Simmons

A. perpunctulata (E.G. Simmons) D.P. Lawr., M.S. Park & B.M. Pryor
(Lawrence & al. 2012, 2013; Woudenberg & al. 2013)
≡ *N. perpunctulata* E.G. Simmons

A. pimpriana V.G. Rao [*]
≡ *N. pimpriana* (V.G. Rao) E.G. Simmons

Alternaria sect. *Alternaria*, indistinguishable taxa

A. dolichi (T.Y. Zhang & G.Z. Zhao) Gannibal [*]
≡ *N. dolichi* T.Y. Zhang & G.Z. Zhao

A. longipes* var. *major Pavgi & U.P. Singh [*]
≡ *N. major* (Pavgi & U.P. Singh) E.G. Simmons

A. nimbyae-dianthi Gannibal [*]
≡ *N. dianthi* T.Y. Zhang & G.Z. Zhao

A. nimbyoides Gannibal [*]
≡ *N. euphorbiicola* W.Q. Chen & T.Y. Zhang

Alternaria sect. *Nimbya*

A. caricis (E.G. Simmons) Woudenb. & Crous
(Pryor & Bigelow 2003; Hong & al. 2005; Lawrence & al. 2013; Woudenberg & al. 2013)
≡ *N. caricis* E.G. Simmons

A. heteroschemos (Fautrey) Gannibal [*]
≡ *N. heteroschemos* (Fautrey) E.G. Simmons

A. juncicola (E.G. Simmons) Gannibal
≡ *N. juncicola* E.G. Simmons

A. scirpicola (Fuckel) Sivan.
(Pryor & Bigelow 2003; Hong & al. 2005; Lawrence & al. 2012, 2013; Woudenberg & al. 2013)
≡ *N. scirpicola* (Fuckel) E.G. Simmons

A. scirpinfestans (E.G. Simmons & D.A. Johnson) Woudenb. & Crous (Lawrence & al. 2012, 2013).
≡ *N. scirpinfestans* E.G. Simmons & D.A. Johnson

A. scirpivora (E.G. Simmons & D.A. Johnson) Woudenb. & Crous (Lawrence & al. 2012, 2013).
≡ *N. scirpivora* E.G. Simmons & D.A. Johnson

Alternaria sect. *Porri*

A. rhapontici (Nelen) Gannibal [*]
≡ *N. rhapontici* (Nelen) E.G. Simmons

Acknowledgments

The author is grateful to Dr. Daniel Lawrence and Dr. Andrew Armitage for their presubmission reviews of this article. This work was supported by Russian Science Foundation (project #14-26-00067).

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Four species of polyporoid fungi newly recorded from Taiwan

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Abstract —Four wood-rotting polypores are reported from Taiwan for the first time: *Ceriporiopsis pseudogilvescens, Megasporia major, Phlebiopsis castanea,* and *Trametes maxima.* ITS (internal transcribed spacer) sequences were obtained from each specimen to confirm the determinations.

Key words—aphyllophoroid fungi, fungal biodiversity, DNA barcoding, fungal cultures, ITS rDNA

Introduction

Polypores are a large group of *Basidiomycota* with poroid hymenophores on the underside of fruiting bodies, which may be pileate, resupinate, or effused-reflexed, and with textures that are typically corky, leathery, tough, or even woody hard (Härkönen & al. 2015). Formerly, polypores were treated mostly in *Polyporaceae* Corda s.l. (under *Polyporales*) and *Hymenochaetaceae* Imazeki & Toki s.l. (under *Hymenochaetales*), with some species in *Corticiaceae* Herter s.l. (Gilbertson & Ryvarden 1986, 1987; Ryvarden & Melo 2014). However, modern DNA-based phylogenetic studies distribute polyporoid genera across at least 12 orders of *Agaricomycetes* Doweld, e.g., *Polyporales* Gäum., *Hymenochaetales* Oberw., *Russulales* Kreisel ex P.M. Kirk & al., *Agaricales* Underw. (Hibbett & al. 2007, Zhao & al. 2015).

Most polypores are wood-rotters that decompose the cellulose, hemicellulose, or lignin of woody biomass in forests; these fungi are either saprobes on trees, stumps, and fallen branches or parasites on living tree trunks or roots and therefore play a crucial role in nutrient recycling for the earth (Härkönen & al. 2015, Ţura & al. 2016). However, some wood-rotting polypores [e.g., *Heterobasidion annosum* (Fr.) Bref. and *Phellinus noxius* (Corner) G. Cunn.] can cause serious plant diseases or decay valuable timber products, resulting in significant economic losses (Dai & al. 2007, Ţura & al. 2016); others [e.g., *Ganoderma lingzhi* Sheng H. Wu & al. and *Taiwanofungus camphoratus* (M. Zang & C.H. Su) Sheng H. Wu & al.] are medicinally important to humans (Cao & al. 2012, Wu & al. 2004).

Taiwan, which lies in the tropical and subtropical zones, is also home to some temperate climates in high montane regions. Numerous mountains and abundant rainfall produce a great variety of forest habitats, hence contributing to high fungal species richness. In Taiwan, polypores have been regionally surveyed for about a century, beginning in the early 1900s. The Japanese mycologist K. Sawada reported 30 wood-rotting polypores in his "Descriptive Catalogue of Taiwan (Formosan) Fungi" (Sawada 1959). Although Taiwanese mycologists (e.g., Z.C. Chen, T.T. Chang, S.H. Wu) have since described new species and reported new polypore records (Tzean & al. 2015), knowledge of wood-rotting polypores in the region is still insufficient.

Here we report as new to the mycobiota of Taiwan four wood-rotting polypores, which we have preserved as fungal cultures and for which we have generated DNA barcoding sequences.

Materials & methods

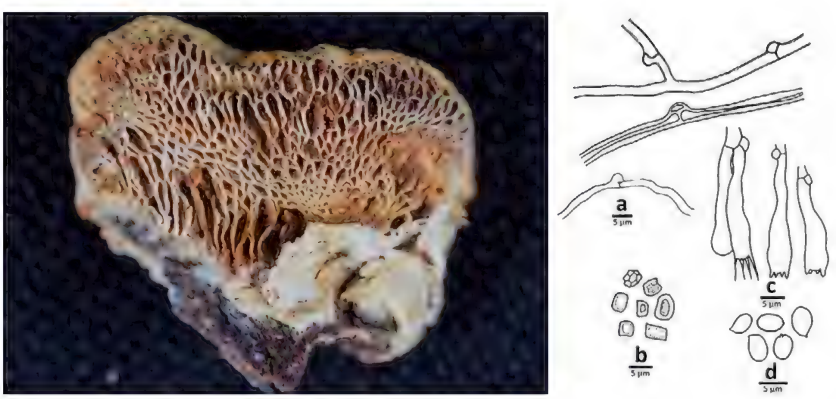
Taiwanese polypore specimens collected in 2012–16 are deposited in the herbarium of National Museum of Natural Science, Taichung, Taiwan (TNM); their cultures are deposited at the Bioresource Collection and Research Center, Hsinchu, Taiwan (BCRC). Descriptions are based on dried basidiocarps. Freehand thin sections of fruiting bodies were prepared with razor blade and mounted in [i] 5% KOH with 1% phloxine stain for observation and measurement of microscopic characters and [ii] Melzer's reagent (IKI) to check amyloidity and dextrinoidity [IKI– indicates inamyloid and nondextrinoid]. Prepared slides were examined at magnifications up to ×1000 with a Leica DM2500 microscope, and line drawings were illustrated with the aid of a drawing tube. Fruiting bodies were photographed in situ or in collection using an Olympus TG-4 or Nikon Coolpix P7100 digital camera.

DNA was extracted from dried specimens or mycelia in pure culture using the Plant Genomic DNA Extraction Miniprep System (Viogene-Biotek Corp.) according

to the manufacturer's protocol. We amplified the ITS rDNA region using commercial primer pairs ITS5/ITS4 or ITS1/ITS4 (White & al. 1990). The MB Mission Biotech Company purified and sequenced the PCR products, and the sequences were used to confirm species determination. Sequences newly obtained in this study were submitted to GenBank (https://www.ncbi.nlm.nih.gov/genbank/).

The scientific binomials of the presented species follow the currently accepted names on MycoBank (http://www.mycobank.org/).

Taxonomy



Figs 1,2: *Ceriporiopsis pseudogilvescens* (Wu 1209-46).
1. In collection. 2. a, generative hyphae; b, crystals; c, basidia; d, basidiospores.

Ceriporiopsis pseudogilvescens (Pilát) Niemelä & Kinnunen, Karstenia 45: 83. 2005. Figs 1,2

Basidiocarps annual, resupinate, adnate, hard and brittle when dry, up to 1.6 cm long, 1 cm wide, and 4.5 mm thick; margin pale cream to straw-colored, sterile, abrupt. Pore surface fawn to cork-colored; pores circular or angular, 2–3 per mm, dissepiments entire, ≤0.2 mm thick. Tubes concolorous with pore surface, ≤3 mm deep. Subiculum cream, homogeneous, fairly dense texture, ≤2 mm thick.

Hyphal system monomitic, hyphae nodose-septate. Subicular hyphae colorless, thin to thick-walled, 2–4 µm diam, occasionally branched. Trama with dense texture. Cystidia and cystidioles lacking. Basidia clavate, with four sterigmata, 10–28 × 5–5.5 µm. Basidiospores broadly ellipsoid, colorless, thin-walled, smooth, IKI–, 4–6 × 2.5–3.2 µm. Cubic to irregular crystals scattered in subiculum.

Specimen examined—**TAIWAN. Nantou county: Jenai Township**, Hohuanshan, 24°09′N 121°17′E, 3150 m a.s.l., on trunk of *Salix* sp., 15.IX.2012, leg. S.H. Wu, Wu 1209-46 (TNM F26731; GenBank KY688203).

Habitat—On angiosperm trunks (e.g., *Betula*, *Populus*, *Salix*) (Ryvarden & Melo 2014).

Type of rot—White rot.

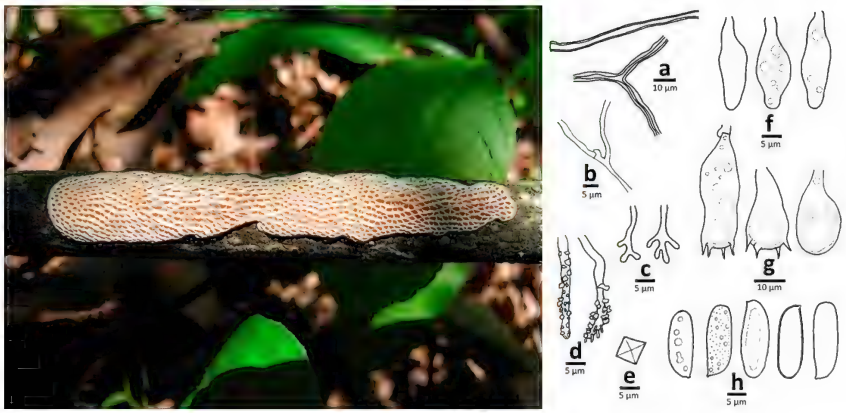
Distribution—Eurasia, East Asia, North America (Ryvarden & Melo 2014).

Remarks—*Ceriporiopsis pseudogilvescens* can be confused with *C. resinascens* (Romell) Domański, which is macroscopically similar (e.g., producing resupinate basidiocarps that become brittle when dry), occurs on the same hosts (e.g., *Betula*, *Populus*, *Salix*), and has an ITS rDNA sequence differing by only five base pairs (Tomšovský & al. 2010). *Ceriporiopsis resinascens* can be distinguished by its smaller pores (3–5 per mm) and narrower basidiospores (4.9–6.2 × 2.2–2.6 µm; Kinnunen & Niemelä 2005). The basidiospore sizes in our specimen match well with those (3.8–6 ×2.6–3.1) recorded for *C. pseudogilvescens* by Kinnunen & Niemelä (2005).

Megasporia major (G.Y. Zheng & Z.S. Bi) B.K. Cui & Hai J. Li, Mycologia 105: 375. 2013. Figs 3,4

Basidiocarps annual, resupinate, at first forming orbicular patches, then broadly effused, adnate, hard corky when dry, up to 12 cm long, 2 cm wide, and 1.5 mm thick; margin sterile, abrupt. Pore surface cream, turning cork-colored when old; pores circular or angular, 1–2 per mm, dissepiments entire, ≤0.25 mm thick. Tubes concolorous with pore surface, ≤1 mm deep; tube walls with hyphal pegs (often lacking in young specimens). Subiculum buff, homogeneous, fairly dense, ≤0.5 mm thick.

Hyphal system dimitic: generative hyphae nodose-septate, skeletal hyphae weakly dextrinoid. Subicular generative hyphae infrequent, colorless, thin-walled, 1–3 µm diam; skeletal hyphae dominant, colorless, thick-walled, 2–4 µm diam, occasionally branched. Trama densely textured. Hymenium thickened. Rare dendrohyphidia and abundant encrusted hyphal ends present in dissepiments. Cystidia lacking. Cystidioles clavate with somewhat acute apices, thin-walled, with several oil droplets, 20–24 × 7–8.5 µm. Basidia clavate to subclavate, with four sterigmata, with one to several oil droplets, 26–40 × 12–14 µm. Basidiospores cylindrical to subcylindrical, colorless,



Figs 3,4: *Megasporia major* (GC 1407-21). 3. On branch of *Cinnamomum osmophloeum*. 4. a, skeletal hyphae; b, generative hyphae; c, dendrohyphidia; d, encrusted hyphal tips; e, crystals; f, cystidioles; g. basidia; h, basidiospores.

thin-walled to slightly thick-walled, smooth, often with oily contents, IKI–, 16–24 × 5.5–7.5 µm. Pyramidal to irregular crystals scattered throughout the section.

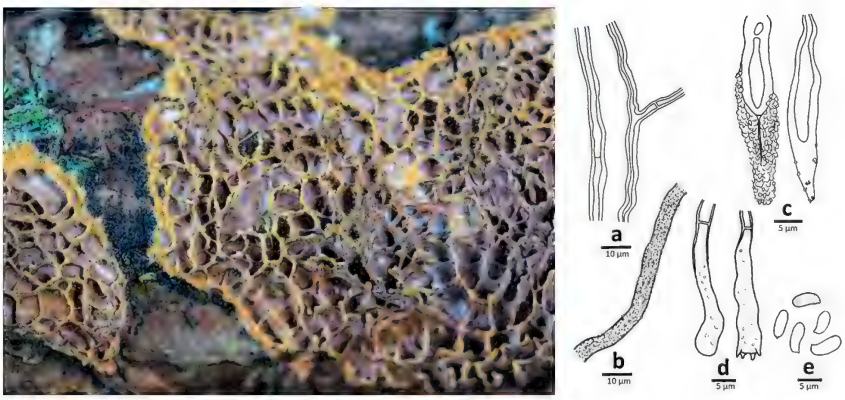
Specimens examined—**TAIWAN. Nantou county: Yuchih Township**, Lienhuachih, 23°56′N 120°53′E, 700 m a.s.l., on branch of *Cinnamomum osmophloeum* Kaneh. (*Lauraceae*), in open *C. osmophloeum* plantation, 18.VII.2014, leg. C.C. Chen, GC 1407-19 (TNM F28458, culture BCRC MU30391, GenBank KY688204); GC 1407-21 (TNM F28460, culture BCRC MU30392, GenBank KY688205); 13.IV.2015, leg. C.C. Chen, GC 1504-35 (TNM F28992); GC 1504-37 (TNM F28993); 24.III.2016, leg. C.C. Chen, GC 1603-30 (TNM F30372).

Habitat—On hanging or fallen angiosperm (e.g., *Cinnamomum*) branches and preferring an open environment (Yuan & al. 2017).

Type of rot—White rot.

Distribution—Known from tropical to subtropical areas of southern China (Guangdong, Hainan) (Dai & al. 2011, Dai & Li 2002) and Taiwan (this study).

Remarks—Within the genus, *Megasporia major* is recognized by its cream-colored pore surface and large pores and basidiospores. Although the basidiospores of the Taiwanese specimens are slightly larger than those described from mainland China (15.2–20 × 5.5–7.1 µm; Dai & Li 2002), our almost identical ITS rDNA sequences confirm the determination.



Figs 5,6: *Phlebiopsis castanea* (GC 1612-6). 5. In collection.
6. a, generative hyphae; b, hyphae covered with yellow resinous material;
c, cystidia; d, basida; e, basidiospores.

Phlebiopsis castanea (Lloyd) Miettinen & Spirin, MycoKeys 17: 25. 2016. Figs 5,6

Basidiocarps annual, resupinate, effused, adnate, corky when dry, up to 14 cm long, 3 cm wide, and 1.5 mm thick; margin sterile, cottony. Pore surface cinnamon; pores irregular or irpicoid, 1–2 per mm, dissepiments pruinose, thin. Tubes paler than pore surface, ≤0.5 mm deep. Subiculum cinnamon, fairly dense texture, ≤0.5 mm thick, composed of basal layer, ≤150 µm thick.

Hyphal system monomitic, generative hyphae simple-septate. Subicular hyphae colorless, agglutinated, thick-walled, 3–8 µm diam, occasionally branched, flexuous, covered with yellow resinous materials that dissolve in KOH. Trama with dense texture. Hymenium thickened. Cystidia projecting, conical to subulate, with acute or obtuse apices, thick-walled, apically heavily encrusted for over half of their lengths, encrustation dissolving in KOH over time, 50–60 × 10–11 µm (encrustation included). Basidia clavate, with four sterigmata, with oily contents, 28–30 × 5–6 µm. Basidiospores broadly allantoid, colorless, thin-walled, smooth, sometimes with oily contents, IKI–, 5–7 × 2–3 µm.

Specimen examined—**TAIWAN. Nantou county: Jenai Township**, Taiwan Forestry Research Institute, Piluchi Experimental Watershed Working Station, 24°13′36″N 121°18′32″E, 2160 m a.s.l., on branch of *Pinus* sp., in road-side, mixed coniferous forest, 3.XII.2016, leg. C.C. Chen, GC 1612-6 (TNM F30913; GenBank KY688208); **Xinyi Township**, Tatachia-Paiyun Villa, 23°29′N 120°55′E, 2700 m a.s.l.,

on branch of *Pinus taiwanensis* Hayata. (*Pinaceae*), 12.XI.1996, leg. S.H. Wu & S.Z. Chen, Wu 9606-19 (TNM F5053). **Taichung city: Heping District**, Pilu, 24°14′N 121°17′E, 2100 m a.s.l., on branch of *P. taiwanensis*, 14.IX.1993, leg. S.H. Wu, Wu 9304-82 (TNM F14863); Siaosyueshan, Tienchih, 24°17′N 121°01′E, 2580 m a.s.l., on branch of *Pinus* sp., 8.XI.2011, leg. S.H. Wu, Wu 1106-15 (TNM F25533).

Habitat—On gymnosperm branch (especially on *Pinus*) (Lim & al. 2005).

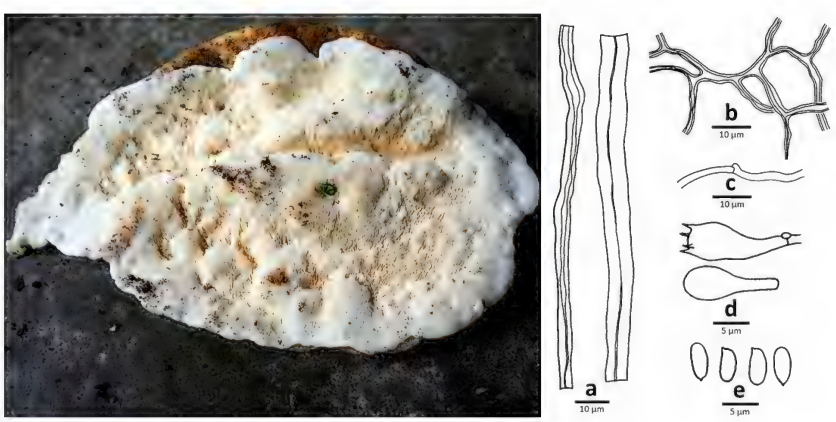
Type of rot—White rot.

Distribution—Known from temperate areas of Asia—China, Japan, Far East Russia, Northern Thailand, Korea—(Dai & Niemelä 1995, Núñez & Ryvarden 2001, Lim & al. 2005) and Taiwan (this study).

Remarks—*Phlebiopsis castanea* is placed in the genus *Phlebiopsis* Jülich based on its poroid cinnamon-colored hymenophore, broadly allantoid basidiospores, and encrusted cystidia. Our specimen produced slightly narrower cystidia while the basidiospore size fits well with previous descriptions (Núñez & Ryvarden 2001, Lim & al. 2005, as *Castanoporus castaneus* (Lloyd) Ryvarden).

Trametes maxima (Mont.) A. David & Rajchenb., Mycotaxon 22: 315. 1985. Figs 7,8

Basidiocarps annual to biannual, sessile, pileate, solitary or imbricate, hard corky when dry. Pilei semicircular to dimidiate, projecting ≤2 cm, ≤7.5 cm wide and ≤6 mm thick at base, margin obtuse. Pileal surface cream-buff to pale cinnamon, becoming greenish due to algal growth, concentrically



Figs 7,8: *Trametes maxima* (GC 1505-33). 7. In situ.
8. a, skeletal hyphae; b, binding hyphae; c, generative hyphae; d, basidia; e, basidiospores.

sulcate, glabrous to tomentose. Pore surface cream-buff; pores angular, 2–4 per mm, dissepiments entire or dentate to lacerate, thin. Tubes concolorous with pore surface, ≤5 mm deep; tube walls bear with abundant hyphal pegs. Context homogeneous, fairly dense texture, ≤1.5 mm thick, separated from pileal surface by a distinct thin black line.

Hyphal system trimitic, generative hyphae nodose-septate. Contextual generative hyphae colorless, thin-walled, 2–2.5 μm diam; skeletal hyphae colorless, thick-walled, 3–10 μm diam, unbranched; binding hyphae colorless, thick-walled, 0.5–2.5 μm diam, intricately branched. Cystidia lacking. Basidia clavate, with four sterigmata, 15 × 5 μm. Basidiospores ellipsoid to cylindrical, colorless, thin-walled, smooth, IKI–, 4.5–5 × 2–2.5 μm.

Specimen examined—**TAIWAN. Taichung city: Tungshih District**, Hsuehshankeng, 24°19′N 120°57′E, 968 m a.s.l., on angiosperm trunk, 30.V.2015, leg. C.C. Chen GC 1505-33 (TNM F29010; culture BCRC MU30393; GenBank KY688213).

Habitat—On angiosperm trunk.

Type of rot—White rot.

Distribution—Known from tropical to subtropical areas of East Asia (Dai 2012, Li & He 2011) and the Americas (United States, Venezuela, Colombia, Brazil) (Gilbertson & Ryvarden 1987, Gomes-Silva & al. 2010).

Remarks—This species is characterized by its concentrically sulcate, glabrous to tomentose pileal surface, the black line in the context towards the pileal surface, its uneven pore surface, and presence of abundant hyphal pegs. Cystidioles were not found in our specimen, but the basidiospore size agrees well with previous descriptions (Gilbertson & Ryvarden 1987, Li & He 2011).

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Four new records of *Leptogium* from China

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Abstract—Four *Leptogium* species are reported as new to China: *L. askotense*, *L. coralloideum*, *L. milligranum*, and *L. subtile*. Descriptions, illustrations, and comments are presented for the four species.

Key words—*Ascomycota*, *Peltigerales*, *Collemataceae*, lichen, taxonomy

Introduction

Forty-two species of the lichen genus *Leptogium* (Ach.) Gray have been reported from China (Wei 1991; Cao & al. 2012; Liu & al. 2010, 2012, 2013, 2014, 2015; Liu & Guan 2012; Wang & al. 2010; Xi & Liu 2014). Here we report *Leptogium askotense*, *L. coralloideum*, *L. milligranum*, and *L. subtile* as new to China. Although the genus was recently re-circumscribed (Otálora & al. 2014, Jaklitsch & al. 2016), we followed the traditional genus concept (Lumbsch & Huhndorf 2007, Kirk & al. 2008) in the present study.

Materials & methods

Morphological and anatomical studies were conducted following Liu & al. (2015). Specimens are deposited in the Herbarium Mycologicum Academiae Sinicae–Lichenes, Beijing, China (HMAS-L) and the Herbarium, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China (KUN).

Taxonomy

Leptogium askotense D.D. Awasthi, Norweg. J. Bot. 24: 63 (1977). Pl. 1a

Thallus foliose, orbicular or irregular in outline, 4–12 cm in diam.; upper surface gray to brown when dry, glabrous, heavily wrinkled, dull or slightly

shiny near margin; LOBES round, 3–10 mm wide, horizontal, entire; ISIDIA and LOBULES absent; LOWER SURFACE paler, densely hairy; HAIRS white, 4–7 µm diam., >100 µm long, composed of a row of cylindrical cells. APOTHECIA abundant, laminal to sometimes submarginal, stalked; DISC red-brown, 2–4 mm in diam., smooth, dull, plane, concave to convex; STALK commonly tubular, not swollen, often with wrinkles and white tomenta; THALLINE MARGIN distinct, concolorous with the thallus, often with tomenta and wrinkles similar to stalk.

THALLUS homoiomerous, 100–250 µm thick; CORTEX on both sides consisting of a single layer of subglobose to irregular, thin-walled cells, 5–10 µm thick; PHOTOBIONT *Nostoc* in chains, 4–7 µm in diam., embedded in a gelatinous layer.

APOTHECIA zeorine, 400–500 µm thick; THALLINE EXCIPLE 100–120 µm thick laterally, with a cortex of a single layer of thin-walled cells; PROPER EXCIPLE euparaplectenchymatous, 50–80 µm thick, consisting of 5–8 layers of subglobose to irregular thin-walled cells; EPIHYMENIUM yellowish, 10–20 µm thick; HYMENIUM 120–150 µm thick; SUBHYMENIUM 40–70 µm thick; ASCI clavate, 8-spored; ASCOSPORES monostichous to distichous, ellipsoid, hyaline, muriform, 5–6-septate transversely, 1–2-septate longitudinally, (15)25–40 × 10–15 µm, obtuse or acute at both ends.

Corticolous.

SELECTED SPECIMENS EXAMINED: **CHINA. SICHUAN PROVINCE**, Mt. Gonggashan, 29°37′N 101°53′E, alt. 2100 m, on bark, 23/VI/1982, X.Y. Wang & al. 8829 (HMAS-L 037125). **YUNNAN PROVINCE**, Lijiang County, Mt. Yulongshan, 27°10′N 100°18′E, alt. 3500 m, on bark, 25/I/2004, L.S. Wang & J. Wang 04-23160 (KUN). **XIZANG PROVINCE**, Zayü County, Mt. Songtaxueshan, 27°43′N 98°39′E, alt. 3400 m, on bark, 26/VI/1982, J.J. Su 2010 (HMAS-L 031687).

REMARKS: *Leptogium askotense* is characterized by the foliose thallus, the wrinkled upper surface, the tomentose and wrinkled thalline margin and stalks, and the euparaplectenchymatous proper exciple. It is reported from Himalayas of India (Awasthi & Akhtar 1977). Our specimens are morphologically similar to those reported from India and extend the species' range to SW China.

Leptogium trichophoroides P.M. Jørg. & A.K. Wallace resembles *L. askotense* in the tomentose, wrinkled thalline margin and the tomentose apothecial stalks, but differs by the darker upper surface and smaller spores (20–25 × 10–12 µm, Cao & al. 2012; 19–22 × 9–10 µm, Jørgensen 1997). *Leptogium delavayi* Hue is similar to *L. askotense* but has glabrous, swollen stalks and a glabrous thalline margin. *Leptogium arisanense* Asahina also resembles *L. askotense* but has sessile apothecia (Asahina 1936, Awasthi & Akhtar 1977, Wang & al. 2010).

Leptogium coralloideum (Meyen & Flot.) Vain.,
Ann. Acad. Sci. Fenn., Ser. A, 6(7): 110 (1915). Pl. 1B,C

Thallus foliose, irregular in outline, 6 cm in diam.; upper surface grayish blue when dry, glabrous, often striate and ridged, dull, isidiate; lobes round, horizontal near center, somewhat erect near margin, <5 mm wide, the margins entire to somewhat lacerate; isidia laminal, mostly on ridges, concolorous with the thallus or darker, not wrinkled, not apically collapsed, granular when young, cylindrical and coralloid when mature; lower surface paler, irregularly striate, with scattered tufts of white hairs.

Thallus homoiomerous, 100–200 μm thick; cortex on both sides consisting of a single layer of irregular, thin-walled cells of 5–7 μm in diam.; photobiont *Nostoc* cells in chains, embedded in a gelatinous layer.

Apothecia not seen.

On mosses.

Specimen examined: **CHINA. Hunan Province**, Sangzhi County, Mt. Tianpingshan, 29°44′N 110°00′E, on moss, 19/VIII/1997, J.B. Chen & D.P. Wang 9606 (HMAS-L 031566).

Remarks: *Leptogium coralloideum* is characterized by the coralloid isidia distributed mainly along ridges on upper surface, and the lower surface with striates and few hairs. It is widely distributed worldwide, especially common in tropical and temperate regions (Aragon & al. 2005, Jørgensen & Nash 2004, Jørgensen 1994). The single specimen from China is morphologically similar to those reported outside the country.

Five coralloid–isidiate species—*Leptogium burnetiae* C.W. Dodge, *L. cyanescens* (Rabenh.) Körb., *L. laceroides* B. de Lesd., *L. lichenoides* (L.) Zahlbr. [≡ *Scytinium lichenoides* (L.) Otálora & al.], and *L. pseudopapillosum* P.M. Jørg.—have been reported in China (Jatta 1902, Wei 1991, Jørgensen 1997, Aptroot & al. 2002, Wang & al. 2010). Both *L. burnetiae* and *L. pseudopapillosum* differ from *L. coralloideum* by the dense, >100 μm long hairs covering the lower surface; *L. lichenoides* differs by its semi-erect to erect lobes and marginal isidia; *L. cyanescens* differs by its thinner lobes and upper surface without ridges; and *L. laceroides* differs by its smooth upper surface and dense hairs on lower surface.

Leptogium milligranum Sierk, Bryologist 67: 290 (1964). Pl. 1D

Thallus foliose, irregular in outline, 4 cm in diam.; upper surface gray-green when dry, glabrous, longitudinally wrinkled, isidiate; lobes irregular or somewhat indistinct, 2–8 mm wide, horizontal, often anastomosing, partly fenestrate, margin incised, occasionally with granular isidia; isidia

laminal, numerous, granular, simple, sometimes also cylindrical and slightly branched, glabrous, without wrinkles; LOWER SURFACE paler, with scattered tufts of white hairs.

THALLUS homoiomerous, 180–280 μm thick; CORTEX on both sides consisting of a single layer of subglobose, thin-walled cells of 4–7 μm in diam.; PHOTOBIONT *Nostoc* cells in chains, embedded in a gelatinous layer.

APOTHECIA not seen.

Corticolous.

SPECIMEN EXAMINED: **CHINA. YUNNAN PROVINCE**, Yimen County, 24°40′N 102°06′E, alt. 1980 m, on bark, 24/IX/2012, L.S. Wang & al. 12-35195 (KUN).

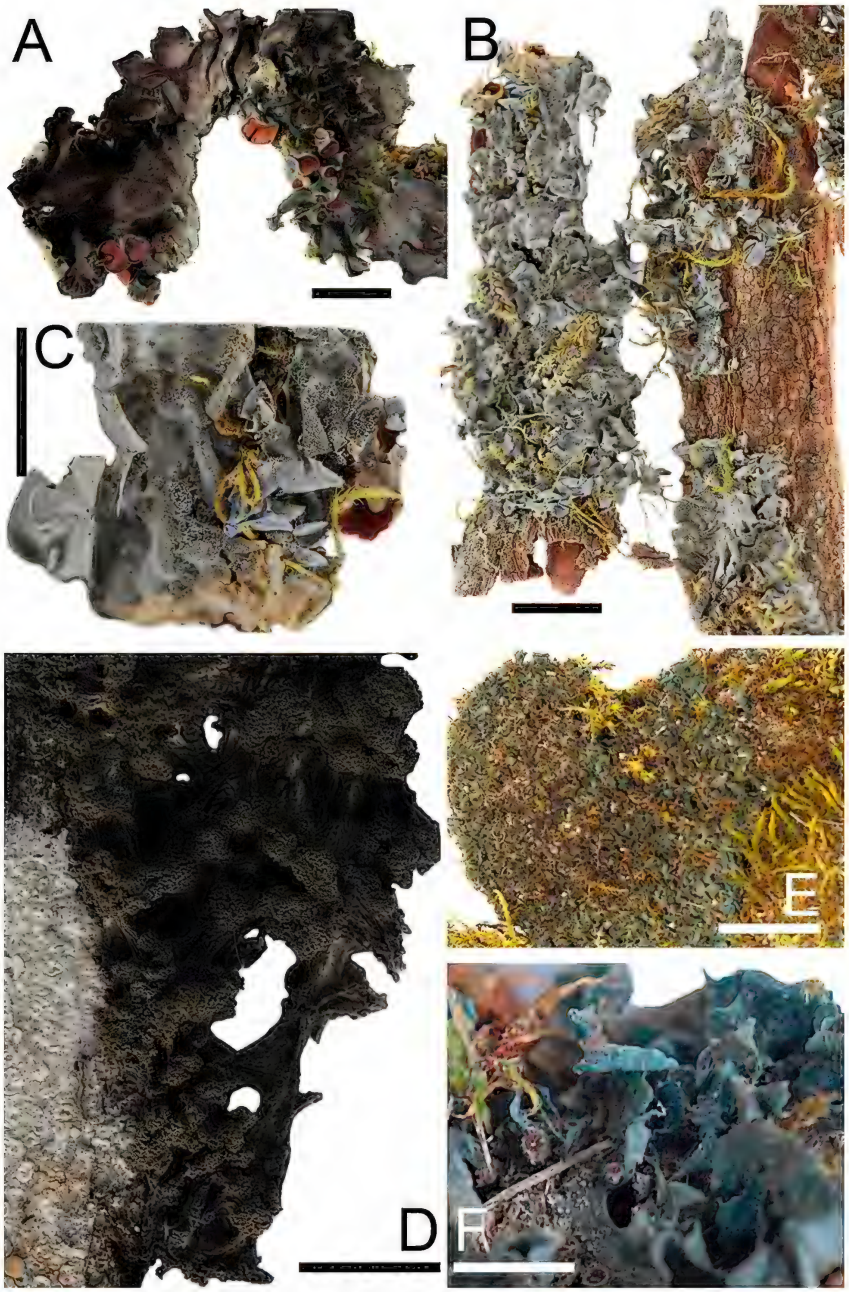
REMARKS: *Leptogium milligranum* is characterized by the green thallus, numerous granular isidia and wrinkles on upper surface, the indistinct, anastomosing lobes, and the sparsely rhizinate lower surface. Four granular-isidiate species—*L. asiaticum* P.M. Jørg., *L. papillosum* (B. de Lesd.) C.W. Dodge, *L. saturninum* (Dicks.) Nyl., and *L. weii* H.J. Liu & S. Guan—have been reported in China (Jatta 1902, Zahlbruckner 1930, Wang & al. 2010, Liu & Guan 2012), but they have distinct, round, non-anastomosing lobes.

Leptogium milligranum has been recorded from North America, Central America, Galápagos Islands, and India (Sierk 1964, Awasthi & Akhtar 1979, Jørgensen & Nash 2004, Bungartz 2008). Our specimen falls within the range of morphological variation of those reported from outside China.

Leptogium subtile (Schrad.) Torss., Enum. Lich. Byssac. Scandin.: 54 (1843). PL. 1E,F

THALLUS minutely foliose, partly forming a pulvinate cushion, irregularly in outline, <4 cm in diam.; UPPER SURFACE bluish when dry, glabrous, smooth, dull; LOBES dense, membranaceous, deeply dissected, 1–2 mm wide near center, <0.5 mm wide near margin, free to suberect at margin, entire; ISIDIA and LOBULES absent; LOWER SURFACE concolorous with upper surface, without wrinkles, with scattered tufts of white hairs. APOTHECIA scattered, laminal, sessile; disc red brown, 0.2–0.4 mm in diam., dull; THALLINE MARGIN persistent, concolorous with thallus or paler, glabrous, entire, without wrinkles and isidia.

PLATE 1. ***Leptogium askotense*** (KUN Wang 04-23160). A. Thallus with apothecia. ***Leptogium coralloideum*** (HMAS-L 031566). B. Thallus; C. Upper surface, showing isidia on ridges. ***Leptogium milligranum*** (KUN Wang 12-35195). D. Thallus, showing dense, granular isidia. ***Leptogium subtile*** (KUN Wang 05-24245). E. Thallus; F. Lobes and apothecia. Scale bars: A = 20 mm; B, D, E = 10 mm; C = 5 mm; F = 2 mm.


A
B
C
D
E
F

Thallus homoiomerous, 40–50 μm thick; cortex on both sides consisting of a single layer of subglobose to slightly irregular, thin-walled cells of 3–6 μm in diam.; photobiont *Nostoc* in chains. Apothecia lecanorine; epithecium yellowish to sometimes brown, about 10 μm thick; hymenium 100–150 μm thick; subhymenium 20–30 μm thick; proper exciple not seen; asci clavate, 8-spored; ascospores colourless, ellipsoid, obtuse at both ends, muriform, 4–6-septate transversely, 1–2-septate longitudinally, 20–30 × 10–12 μm.

On moss-covered barks.

Specimen examined: **CHINA. Yunnan Province**, Yuanyang County, Huangcaoling Town, 22°57′N 102°37′E, alt. 1200 m, on bark, 16/I/2005, L.S. Wang 05-24245 (KUN).

Remarks: *Leptogium subtile* is easily distinguished from other species in China by its minutely foliose and thin thallus, dissected, narrow and membranaceous lobes, smooth upper surface, and small, sessile apothecia. It was previously known from North America, Europe, and Asia (Jørgensen 1994, Kashiwadani & al. 2002, Jørgensen & Nash 2004, Aragón & al. 2005). It is rare in China with only one collection, which falls in the range of morphological variation of those from outside China.

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Castanediella diversispora sp. nov. from the Brazilian Atlantic Forest

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Abstract—*Castanediella diversispora*, collected from decaying leaves of an unidentified plant in Pernambuco state, Brazil, is described and illustrated as a new species characterized by three conidial morphologies: i) cylindrical, with both ends uncinate, ii) cylindrical to subacerose with an uncinate apex and attenuated base, iii) and long filiform with an obtuse apex and attenuated base. A key to *Castanediella* species is provided.

Key words—asexual ascomycete, hyphomycete, taxonomy, tropical fungi

Introduction

The Brazilian Atlantic Forest, regarded as the oldest Brazilian forest, is considered a complex biome that contains a species' diversity higher than most Amazon forests and with extremely high levels of endemism (Colombo & Joly 2010, Rizzini 1997). Several studies in the forest have revealed novel

taxa and new records of conidial fungi (Barbosa & al. 2016, Costa & al. 2016a,b, Marques & al. 2008, Oliveira & al. 2015). During a mycological survey of microfungi associated with leaf litter in the Brazilian Atlantic Forest, we collected a striking fungus that is described as a new *Castanediella* species.

Materials & methods

Individual collections were placed in plastic bags, taken to the laboratory, and treated according to Castañeda-Ruiz & al. (2016). Mounts were prepared in lactic acid (90%) or (following Carmichael 1955) polyvinyl alcohol-glycerol (8 g PVA in 100 mL of water + 5 mL of glycerol) and lactofuchsin (0.1 g acid fuchsin, 100 mL 85% lactic acid). Microscopical characters were measured at ×1000 using an Olympus CX41 microscope with phase contrast optics and photographed using a Nikon Eclipse Ni-U microscope with DIC optics and a Nikon DS-Fi2 camera. The holotype is deposited in the Herbarium of Universidade Federal de Pernambuco, Recife, Brazil (URM).

Taxonomy

Castanediella diversispora P.M.O. Costa, Malosso & R.F. Castañeda, **sp. nov.**

MycoBank MB824478 Figs 1, 2

Differs from *Castanediella cagnizarii* by its conidia that are 1–3-septate with scolecospore-like shape.

Type: Brazil, Pernambuco, Igarassú, RPPN Refúgio Ecológico Charles Darwin, 7°48′S 34°57′W, on decaying leaves of an unidentified plant, 12.V.2017, coll. P.M.O. Costa (**Holotype**, URM 90135).

Etymology: Latin, *diversi-*, means diverse, varied, or different + *-spora*, referring to the conidia.

Conidiomata on the natural substrate sporodochia, scattered, sometimes coalescent amphigenous, slightly pulvinate, yellowish-white or white. Mycelium mostly superficial, composed of septate, branched, pale brown or brown, smooth-walled hyphae, 1–2.5 µm diam. Conidiophores micronematous or semi-macronematous erect, forming a compact cluster, pale brown to brown, smooth-walled. Conidiogenous cells polyblastic, discrete, sympodial, minutely denticulate at the inflated apex, arising terminally and laterally from the superficial hyphae, pale brown to brown, smooth-walled, 4–9 × 2–3.5 µm. Conidial secession schizolytic. Conidia solitary, acrogenous, hyaline, smooth-walled, exhibiting three different conidial morphologies: i) cylindrical, slightly uncinate at the ends, straight, 1-septate, 11.5–16 × 2 µm; ii) cylindrical to slightly subacerose, slightly uncinate at the apex, abruptly attenuated at the base, straight, 1-septate, 19.5–25 ×

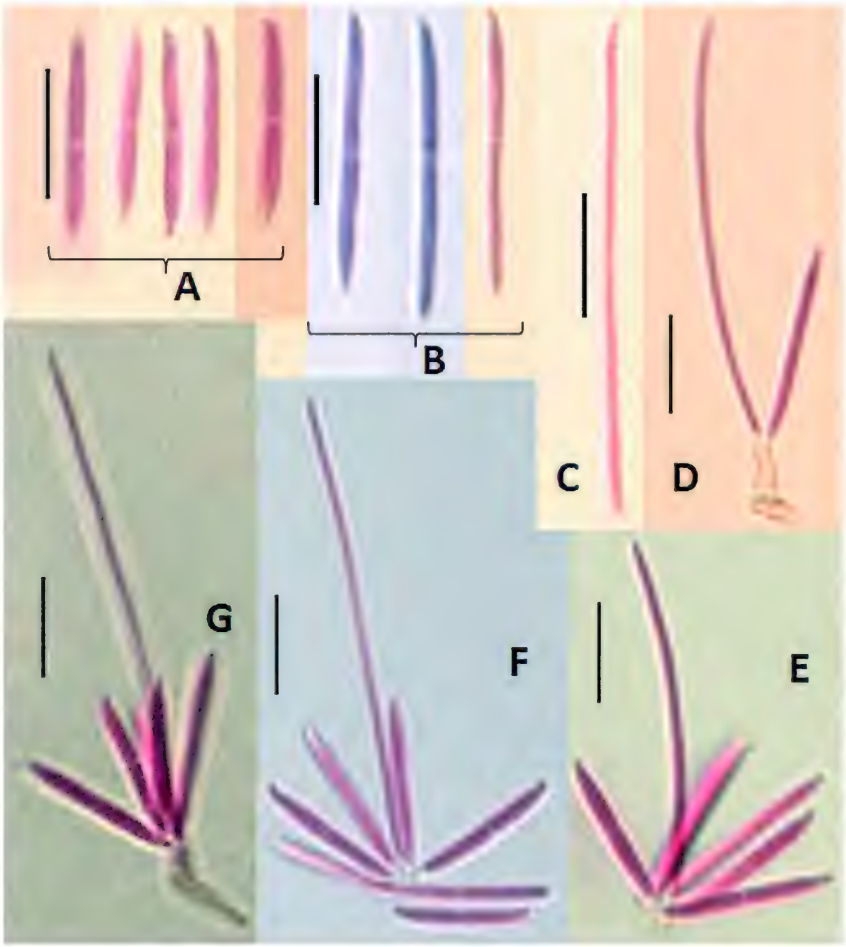

Fig 1. *Castanediella diversispora* (ex holotype, URM 90135). A–C. Conidia. D. Conidiogenous cell and conidia. E–G. Fascicles containing one long filiform conidium. Scale bars = 10 µm.

1.5–2 µm; iii) long filiform, obtuse or rounded at the apex attenuated at the base, straight or curved, 1–3-septate, 28.5–47 × 1 µm.

Notes: Crous & al. (2015a) established the genus *Castanediella* Hern.-Restr. & al., typified by *C. acaciae;* its nine other species are *C. cagnizarii, C. communis, C. couratarii, C. eucalypti, C. eucalypticola, C. eucalyptigena, C. hyalopenicillata, C. malaysiana,* and *C. ramosa* (Crous & al. 2015a,b, 2016, 2017; Crous & Wingfield 2016; Hernández-Restrepo & al. 2016a,b). The

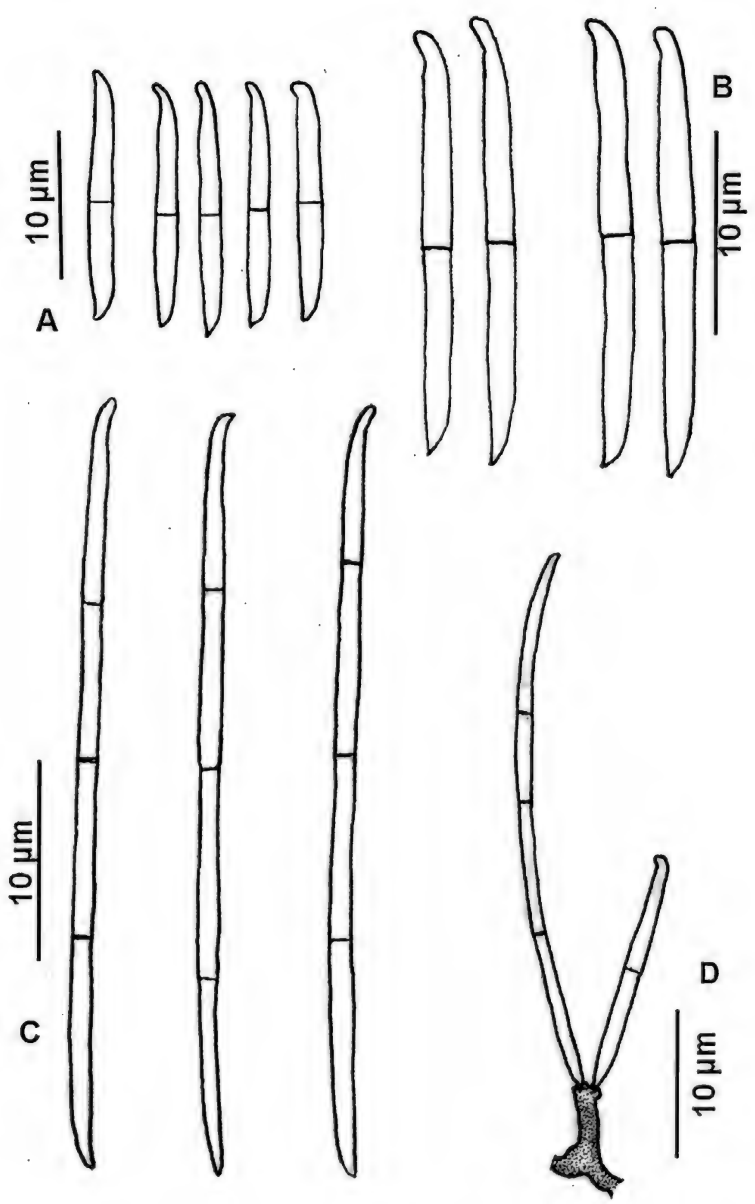

Fig 2. *Castanediella diversispora* (ex holotype, URM 90135), A. Cylindrical conidia with uncinate ends. B. Cylindrical to subacerose conidia with uncinate apex and attenuated base. C. Long filiform conidia with obtuse apex and attenuated base. D. Conidiogenous cell and conidia.

genus *Castanediella* is distinguished by conidiomata that are sporodochial, scattered, sometimes coalescent, pulvinate, punctate or rudimentary, white to yellow, and composed of branched, compact, penicillate, pale brown or brown conidiophores with conidiogenous cells that are polyblastic, sympodial cylindrical, lageniform or subulate, terminal or discrete, and denticulate (usually with numerous inconspicuous teeth at the inflated apex). The conidia are falcate, lunate, subcylindrical, fusiform or clavate, unicellular or septate, hyaline, and smooth.

Castanediella diversispora resembles *C. cagnizarii* (R.F. Castañeda & W.B. Kendr.) Crous & al., which differs by its (0–)1-septate, cylindrical or fusiform conidia that are usually curved at both ends, with two sizes: 12–17 × 1.5–2 µm and 21–25 × 1.5–2 µm (Castañeda-Ruiz & Kendrick 1991).

Key to *Castanediella* species

1. Conidia falcate or lunate 2
1. Conidia not as above 9
2. Conidia always 0-septate 3
2. Conidia 0–3-septate 7
3. Conidiophores branched 4
3. Conidiophores unbranched 5
4. Chlamydospores absent; conidia falcate with subobtuse ends, biguttulate, 8–12 × 1.5–2 µm ..... *C. acaciae*
4. Chlamydospores globose, brown, 4–10 µm diam, forming in chains; conidia falcate with subobtuse ends, guttulate, (13–)17–20(–22) × 2–3 µm ..... *C. communis*
5. Conidiophores frequently reduced to conidiogenous cells, conidia falcate with subobtusely rounded acute ends, biguttulate, (13–)18–24(–30) × 2(–2.5) µm, aggregated in mucoid clusters .. *C. eucalyptigena*
5. Conidiophores not reduced to conidiogenous cells 6
6. Conidia falcate with subobtuse apex and truncate base, biguttulate, (15–)20–26(–30) × 2.5–3 µm ..... *C. eucalypticola*
6. Conidia falcate with two subobtuse ends, (15–)18– 21(–23) × 2–3 µm ..... *C. eucalypti*
7. Chlamydospores absent, conidia falcate to lunate, 18–30 × 2–3 µm ... *C. malaysiana*
7. Chlamydospores present 8
8. Chlamydospores globose or subglobose, intercalary or in branched chains, brown, conidia lunate, 0(–1)-septate, 10–22 × 1.5–2.5 µm ..... *C. couratarii*
8. Chlamydospores elliptical or globose, brown, conidia falcate, (0–)1(–3)-septate, 26–44 × 2–3 µm ..... *C. ramosa*

9. Conidia uniform in shape and size: cylindrical, subacerose to fusiform, apex obtuse, base pointed, 0–1-septate, 14–24 × 2–3 µm .... *C. hyalopenicillata*

9. Conidia not uniform in shape and size 10

10. Conidia cylindrical or fusiform, usually 1-septate and curved at both ends (apex sometimes obtuse), of two sizes: 12–17 × 1.5–2 µm and 21–25 × 1.5–2 µm ..... *C. cagnizarii*

10. Conidia in three shapes and sizes, i) cylindrical, 1-septate, 11.5–16 × 2 µm; ii) cylindrical to slightly subacerose, 1-septate, 19.5–25 × 1.5–2 µm; iii) long filiform, 1–3-septate, 28.5–47 × 1 µm ..... *C. diversispora*

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The authors express their sincere gratitude to Dr. Margarita Hernández-Restrepo and Dr. De-Wei Li for their critical review of the manuscript. The authors are grateful to Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for financial support (Project 88881.062172/2014-01) and Programa Ciência sem Fronteiras. RFCR is grateful to the Cuban Ministry of Agriculture for facilities. DS is grateful to the Escuela Superior Politécnica del Litoral (ESPOL), CIBE, for financial support. We acknowledge the websites provided by Dr. P.M. Kirk (Index Fungorum) and Drs. V. Robert and K. Bensch (MycoBank). Dr. Lorelei Norvell's editorial review and Dr. Shaun Pennycook's nomenclature review are greatly appreciated.

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Varicellaria emeiensis sp. nov. and a review of the genus in China

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Abstract—A new species, *Varicellaria emeiensis*, is described from Sichuan Province, southwest China. It is characterized by its lecanorate apothecia with heavily white-pruinose discs, 8-spored ascus, and the presence of lecanoric acid. Additional material is reported for four *Varicellaria* species previously recorded from China, and a key is provided to the five species known from China.

Key words—*Ochrolechiaceae*, *Pertusariales*, lichens, taxonomy

Introduction

The circumscription of *Varicellaria* Nyl. was enlarged by Schmitt & al. (2012), a genus now characterized by its disciform ascomata, non-amyloid hymenial gel, strongly amyloid asci, 0–1-septate ascospores with thick one-layered walls, and the presence of lecanoric acid. All the described species contain lecanoric acid, and may also contain lichexanthone or variolaric acid (Schmitt & al. 2012).

In China, *Varicellaria rhodocarpa* was first reported by Ren & al. (2003), and *V. lactea* by Ren & Li (2013), and Zhao & al. (2004) and Ren (2011) reported two other *Varicellaria* species as *Pertusaria*. During the revision of *Varicellaria* in China, some specimens identified as *Pertusaria carneopallida* by Ren (2011) and *Ochrolechia pallescens* by Ren & Jia (2011) have been reexamined, revealing a new species, described here as *Varicellaria emeiensis*.

Material & methods

The holotype specimen is conserved in the lichen herbarium of Herbarium Mycologicum, Chinese Academy of Sciences, Beijing, China (HMAS-L); other examined specimens are preserved in CANL, HMAS-L, KUN, SDNU, and TNS-L. The morphology of all specimens was studied using an Olympus SZX16 stereomicroscope and an Olympus BX61 compound microscope and photographed using an attached Olympus DP72 digital camera. The secondary metabolites were identified by spot tests and thin-layer chromatography (TLC) using solvents A, B, and C (Elix 2014).

Taxonomy

Varicellaria emeiensis Q. Ren, **sp. nov.** Pl. 1

Fungal Name FN 570520

Differs from *Varicellaria velata* by its 8-spored asci and much smaller ascospores and from *Pertusaria carneopallida* by the presence of lecanoric acid.

Type: China: Sichuan, Mt. Emei, alt. 3160 m, on *Abies* sp., 17 Aug. 1963, Zhao & Xu 07669 (**Holotype**, HMAS-L 0019875).

Etymology: The specific epithet *emeiensis* refers to the locality of the type collection, Mt. Emei, located in Sichuan Province, southwest China.

Thallus grey, thin, prothallus absent, not zoned, surface slightly tuberculate, shiny or dull; soredia and isidia absent. Apothecia lecanorate, round to irregular, numerous, well dispersed, concolourous with thallus, mostly single, rarely 2–3 fused, 0.7–0.8(–1) mm diam.; disc pale red-brown, plane, covered with heavily white pruina; epithecium hyaline to brownish, K–; hypothecium hyaline; ascospores 8 per ascus, uniseriate or irregularly biseriate, round or ellipsoidal to broad-ellipsoidal, 20–27.5 × 12–20 µm; ascospore wall smooth, 2–3 µm thick, and end wall not trimmed.

Chemistry—cortex K–, C–, KC–, Pd–, UV–; medulla K–, C+ red, KC+ red, Pd–. Lecanoric acid (TLC).

Additional specimens examined: **China: Sichuan, Mt. Emei,** Qianfo Ding, 3100 m, on bark, 14 Nov. 1964, Wei 2253 (HMAS-L: Ren 2011 (as *Pertusaria carneopallida*); Jinding, 3160 m, on *Abies* sp., 17. Aug. 1963, Zhao & Xu 7775, 7968, 7875, 7971 (HMAS-L); on *Abies* sp., 19 Apr. 1994, Wei s. n. (HMAS-L; Ren & Jia 2011 (as *Ochrolechia pallescens*); 3050 m, on bark, 27 Sept. 2001, Jia S243 (HMAS-L); Xixiang Chi, 2200 m, on bark of broadleaf tree, 14 Aug. 1963, Zhao & Xu 7367 (HMAS-L); Taizi Ping, 2800 m, on rotten wood, 18. Aug. 1963, Zhao & Xu 8190 (HMAS-L).

Comments—*Varicellaria emeiensis,* which is characterized by its lecanorate apothecia with heavily white-pruinose discs, 8-spored ascus, and the presence of lecanoric acid, was erroneously reported from Mt. Emei in China as *Pertusaria carneopallida* (Nyl.) Anzi ex Nyl. by Ren (2011) and *Ochrolechia pallescens*

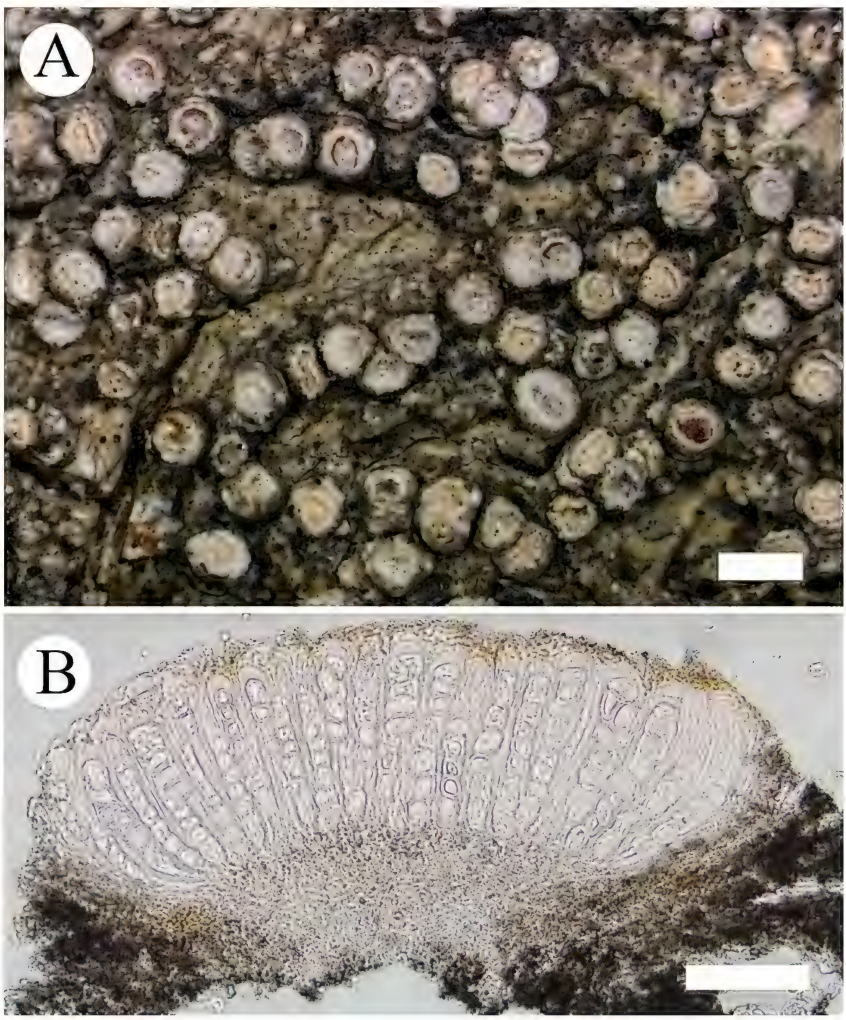

Plate 1. *Varicellaria emeiensis* (holotype, HMAS-L 0019875). A. Thallus showing disciform apothecia with heavy white pruina and red-brown disc; B. Apothecium cross-section showing 8-spored ascus. Scale bars: A = 1 mm, B = 100 μm.

(L.) A. Massal. by Ren & Jia (2011). *Varicellaria emeiensis* morphologically resembles *V. velata* and *Pertusaria carneopallida; V. velata* is distinguished by producing one much larger (160–250 μm long) ascospore per ascus, while *P. carneopallida* contains gyrophoric acid (Dibben 1980).

Varicellaria hemisphaerica (Flörke) I. Schmitt & Lumbsch, Mycokeys 4: 29 (2012).

Thallus bluish-gray; prothallus white, distinct, zoned; soralia white, convex, 0.3–1.5 mm in diam., often confluent; soredia granular; on well-lit tree bark. Apothecia not seen.

Chemistry—cortex K–, C–, KC–, Pd–, UV–; medulla and soralia K–, C+ red, KC+ red, Pd–. Lecanoric acid (TLC).

Selected specimens examined: **China: Fujian, Mt. Wuyi,** Zhumu Gang, 1480 m, on bark, 4 Oct. 1981, Qian 03084 (HMAS-L). **Sichuan, Mt. Emei,** Jinding, 3160 m, on bark, 17 Aug. 1963, Zhao & Xu 7905 (HMAS-L). **Xizang, Chayu Co.,** Chawalong Town, 3800 m, on bark, 27 Sep. 1982, Su 5020 (HMAS-L). **Yunnan, Zhongdian Co.** [now Xianggelila Co.], Bigu Forest Farm, 2300 m, on *Picea* sp., 13 Aug. 1981, Wang & al. 5345 (HMAS-L).

Comments—*Varicellaria hemisphaerica*, growing on rough, well-lit, lower part of trunk, very rarely on rock, is characterized by its pale bluish-grey tinged thallus; conspicuous, paler or concolorous, and convex soralia; and the presence of lecanoric acid (Chambers & al. 2009, as *Pertusaria hemisphaerica*). It might be confused with *Ochrolechia androgyna* (Hoffm.) Arnold and *V. lactea*. *Ochrolechia androgyna* is distinguished by a grey-white thallus containing gyrophoric and fatty acids and the absence of a prothallus (Ren 2017). When growing on rock, *V. hemisphaerica* resembles *V. lactea*, which differs in its white, regularly rimose-cracked thallus; only slightly convex, pure white, discrete soralia; and growth on well-lit, dry siliceous rock (Ren & Li 2013).

This species has been reported from Fujian, Xizang, and Sichuan Provinces as *Pertusaria hemisphaerica* (Ren & Zhao 2004, Zhao & al. 2004, Ren 2011). Specimens erroneously reported as (1) *P. hemisphaerica* from Yunnan Province by Zhao & al. (2004), Ren & Zhao (2004), and Ren (2011) should be revised as *Ochrolechia mahluensis* Räsänen (Ren 2017) and (2) *P. hemisphaerica* from Gansu Province by Yang & al. (2008) contain picrolichenic acid and are assigned to *Lepra amara* (Ach.) Hafellner.

Varicellaria lactea (L.) I. Schmitt & Lumbsch, Mycokeys 4: 31 (2012).

Thallus white to grey-white, thick, smooth, dull, regularly rimose-areolate; prothallus distinct, often zoned; soralia white, scattered, rounded, 0.5–1.5 mm in diam.; often on dry, siliceous rock. Apothecia not seen.

Chemistry—cortex K–, C+ yellowish, KC+ red, Pd–, UV–; medulla and soralia K–, C+ red, KC+ red, Pd–. Lecanoric and variolaric acids (TLC).

Selected specimens examined: **China: Heilongjiang, Tahe Co.,** Baikalu Shan, 800 m, on rock, 25 Aug. 2011, Cheng 20125512 (SDNU). **Jilin,** Mt. Changbai, Changbai Waterfall, 1950 m, on rock, 20 Jul. 2014, Hu 20141175 (SDNU). **Nei Menggu, Aershan**

City, Jiguan Shan, 1400 m, on rock, 29 Aug. 2011, Jiang 20124938, 20124759 (SDNU). **Shaanxi, Mt. Taibai,** Paomaliang, 3600 m, on granite, 30 Dec. 1963, Ma & Zong 256 (HMAS-L). **Yunnan, Jianchuan Co.,** Shibao Shan, 2640 m, on siliceous rock, 17 Aug. 2011, Ren 1745 (SDNU).

Comments—*Varicellaria lactea* is characterized by its white-grey thallus with a regularly rimose-areolate surface; round, white soralia; the presence of lecanoric and variolaric acids; and the substrate of dry, siliceous or slightly calcareous rock. Apothecia were not seen in Chinese material (Ren & Li 2013). This species might be confused with *V. hemisphaerica,* which is distinguished by a pale blue-grey thallus with paler convex soralia. *Lepra excludens* (Nyl.) Hafellner also occurs on rocks but produces a C– medulla and soralia.

Varicellaria rhodocarpa (Körb.) Th. Fr., Lich. Scand. 1: 322 (1871).

Thallus thin, smooth, shiny, epruinose, whitish to yellowish, isidia and soredia absent. Fertile verrucae scattered, 0.5–1.2 mm in diam. Apothecia 1 or 2–3 per verruca, with pinkish or yellowish disc; asci 1-spored; ascospores hyaline, 1-septate, 227–270 × 55–110 µm; ascospore walls 10–27 µm thick.

Chemistry—cortex K–, C–, KC–, Pd–, UV– or + orange; medulla K–, C+ red, KC+ red, Pd–. Lecanoric acid, ± lichexanthone (TLC).

Selected specimens examined: **CHINA: Gansu, Wenxian Co.,** Qiujiaba, 2550 m, on bark, 3 Aug. 2007, Yang 20070152 (SDNU). **Shaanxi, Ningshan Co.,** Pingheliang, 2200 m, on bark, 28 Jul. 2005, Zhao 965 (HMAS-L). **Xizang, Chayu Co.,** Zhula Pass between Azha and Lagu Yangge, 4150 m, on moss, 12 Aug. 1973, Zhang s.n. (HMAS-L). **Yunnan, Xianggelila Co.,** Shika Snow Mountain, 4100 m, on bark, 2 Nov. 2008, Sun 20081976 (SDNU).

Comments—*Varicellaria rhodocarpa* is an arctic-alpine species growing on bark, rock, or mosses that has been reported from Europe, North America, and Japan (Oshio 1968). This species, characterized by its large, 2-celled ascospores (227–270 µm long), was first reported in China by Ren & al. (2003). The specimens examined indicate two chemotypes: the common chemotype of the species containing lecanoric acid only, and chemotype 2 with additional lichexanthone. *Varicellaria rhodocarpa* resembles a poorly developed *V. velata*, which is otherwise distinguished by a 1-celled ascospore.

Varicellaria velata (Turner) I. Schmitt & Lumbsch, Mycokeys 4: 31 (2012).

Thallus grey-white, smooth to wrinkled and rimose-cracked, shiny or dull; prothallus distinct, zoned; isidia and soredia absent. Apothecia disk-like, abundant, well-scattered, rarely confluent, 0.2-1.0 mm in diam., with pinkish or yellowish disc covered with white pruina; asci 1-spored; ascospores hyaline, large, 160–250 × 60–80µm; ascospore walls 10-31 µm.

Chemistry—cortex K–, C–, KC–, Pd–, UV– or + orange; medulla K–, C+ red, KC+ red, Pd–. Lecanoric acid, ± lichexanthone (TLC).

Selected specimens examined: **China**: **Anhui**, **Huoshan Co.**, Baimajian, 1200 m, on bark, 9 Jun. 2011, Dong 20113177 (SDNU). **Fujian**, **Wuyishan City**, Tongmu Village, 1200 m, on bark, 26 Oct. 2010, Li 20105773 (SDNU). **Gansu**, **Zhouqu Co.**, Huacaopo, 3300 m, on *Abies* sp., 29 Jul. 2006, Yang & Shi 060935 (SDNU). **Guangxi**, **Tianlin Co.**, Cenwanglao Shan, 1900 m, on bark, 23 Mar. 2011, Li 20110677 (SDNU). **Guizhou**, **Mt. Fanjing**, near Chengen Temple, 27°54′N 108°41′E, 2120 m, on bark of broadleaf tree, 8 Oct. 2012, Ren 2165 (SDNU). **Hainan**, **Wuzhishan City**, at the foot of Wuzhi Shan, on bark, 20 Apr. 1993, Jiang & Guo H-1030-1 (HMAS-L). **Heilongjiang**, **Yichun City**, Liangshui National Nature Reserve, 48°04′N 129°09′E, 305 m, on bark, 28 Aug. 2014, Wei & al. HLJ201400944 (HMAS-L). **Hubei**, **Shennongjia**, 2830 m, on bark, 9 Jul. 1984, Wu 8400528 (HMAS-L). **Hunan**, **Sangzhi Co.**, Bagong Shan, 1400 m, on *Castanea mollissima*, 24 Nov. 2010, Li 20106288 (SDNU). **Jiangxi**, **Mt. Lushan**, Xiao Tianchi, on bark, 15 Jun. 1955, Wu 550035 (HMAS-L). **Jilin**, **Helong City**, Zengfeng Shan, 1600 m, on bark, 19 Aug. 2011, Cheng 20120288 (SDNU). **Liaoning**, **Kuandian Co.**, Baishilazi Nature Reserve, 40°52′N 124°47′E, 450 m, on rock, 8 Sep. 1989, Chen 7186 (CANL). **Shaanxi**, **Mt. Taibai**, on the roadside between Dadian and Doumu Temple, 2650 m, on siliceous rock, 3 Aug. 2005, Ren 05-224 (SDNU). **Sichuan**, **Jiuzhaigou Co.**, the Long Lake, 33°02′27″N 103°56′06″E, 3060 m, on *Picea* sp., 12 Aug. 2016, Ren 4312 (SDNU). **Taiwan**, **Taizhong Co.**, Rengechi, 31 Dec. 1925, Asahina 263 (TNS-L). **Xizang**, **Chayu Co.**, the north slope of Songta Snow Mountain, 3200 m, on bark, 26 Jun. 1982, Su 1778 (HMAS-L); **Bomi Co.**, near Baka Village, 30°03′32″N 95°11′50″E, 2671 m, on rotten wood, 7 Sep. 2014, Wei & Wang XZ20140339 (HMAS-L). **Yunnan**, **Lijiang City**, Lijiang Alpine Botanical Garden, 3210 m, on *Quercus pannosa*, 16 Aug. 2011, Ren 1553, 1556 (SDNU); **Weixi Co.**, Laowu Houshan, 2600 m, on bark, 21 May 1982, Wang 82-344 (KUN); Dali City, Mt. Cangshan, 3000 m, on branch, 14 Aug. 2011, Ren 1385 (SDNU); **Xiangelila Co**, Tiansheng Bridge, 3500 m, on bark, 3 Nov. 2008, Sun 20081262 (SDNU). **Zhejiang**, **Tiantai Shan**, near the peak of Huading Shan, 910 m, on bark, 23 Aug. 1986, Qian 04336 (HMAS-L).

Comments—*Varicellaria velata*, a cosmopolitan species growing on various substrates, is widespread in China (Zhao & al. 2004, Ren 2011, as *Pertusaria velata*). This species is characterized by its disciform ascomata with pruinose to sorediate discs, 1-spored asci, and the presence of lecanoric acid in all specimens and additional lichexanthone in some specimens. The specimens examined indicate two chemotypes: the common chemotype containing lecanoric acid only and chemotype 2 with additional lichexanthone. *Varicellaria velata* resembles *Ochrolechia pallescens*, which is distinguished by 8-spored asci, much smaller (52–72 × 26–34 μm) ascospores, and the presence of gyrophoric, lecanoric, variolaric, and alecotoronic acids (Ren 2017).

Key to the species of *Varicellaria* known in China

1a. Ascospores 2-celled. . . . . *V. rhodocarpa*
1b. Ascospores 1-celled or absent 2

2a. Thallus esorediate 3
2b. Thallus sorediate 4
3a. Asci 1-spored; lecanoric acid (sometimes with additional lichexanthone). . ***V. velata***
3b. Asci 8-spored; lecanoric acid. ..... ***V. emeiensis***
4a. Thallus corticolous (rarely saxicolous); lecanoric acid. ..... ***V. hemisphaerica***
4b. Thallus saxicolous; lecanoric and variolaric acids ..... ***V. lactea***

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Teuvoa saxicola and *T. alpina* spp. nov. and the genus in China

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Abstract—Two new species, *Teuvoa saxicola* and *T. alpina*, are described from China. *Teuvoa saxicola* differs from other *Teuvoa* species by its saxicolous habitat, and its yellow brown, thick thallus. *Teuvoa alpina* resembles *T. junipericola* from western USA, but differs by its smaller ascospores and its higher altitude habitat. The morphological characters of the new species are illustrated. New material is described of *T. tibetica*, the only species previously recorded from China. The morphological and phylogenetic characteristics of the three species are discussed and compared with similar taxa.

Key words—*Megasporaceae*, *Pertusariales*, *Lobothallia*, lichens, taxonomy

Introduction

The lichen genus *Teuvoa* Sohrabi & S.D. Leav. (*Pertusariales*, *Megasporaceae*) was established based on the analysis of molecular sequence data and morphological characters (Sohrabi & al. 2013). The lichen family *Megasporaceae* has six genera: *Aspicilia*, *Circinaria*, *Lobothallia*, *Megaspora*, *Sagedia*, and *Teuvoa* (Schmitt & al. 2006, Lumbsch & al. 2007, Nordin & al. 2010, Sohrabi & al. 2013). Phylogenetic analysis by Sohrabi & al. (2013) supports *Teuvoa* as the sister group to *Lobothallia*.

Teuvoa is characterized by its 8-spored asci, absence of extrolites, rather short conidia and ascospores, lack of a subhypothecial algal layer, and different substratum preferences (Sohrabi & al. 2013). Worldwide, there are three described *Teuvoa* species: the terricolous *T. tibetica* and the epiphytic *T. junipericola* Sohrabi & S.D. Leavitt and *T. uxoris* (Werner) Sohrabi & al. (Rico & al. 2007; Sohrabi & al. 2010, 2013). During research on *Aspicilia* s. lat. in China's

arid and semi-arid regions, two saxicolous specimens from different localities and seven lignicolous specimens on conifers were collected. Morphological characters placed these specimens in *Teuvoa*, a placement confirmed by ITS sequence analyses. The saxicolous specimens are proposed here as a new species, *Teuvoa saxicola*, and the lignicolous specimens as a new species, *T. alpina*. New specimens are reported for *T. tibetica*, the only *Teuvoa* species previously recorded from China.

Material & methods

Morphological & chemical studies

Specimens collected from arid and semi-arid regions in northwestern China and preserved in the herbarium of Shandong Normal University, Jinan, China (SDNU), and the lichen herbarium of Herbarium Mycologicum, Chinese Academy of Sciences, Beijing, China (HMAS-L), were examined using an Olympus SZ51 dissecting microscope and Olympus CX41 compound light microscope. Apothecial sections were cut by hand and studied in water. Thalline cortex and medulla were spot tested (K, C, KC, I), and lichen substances were assessed in all samples by thin-layer chromatography (TLC) with solvent systems A, B, & C (Orange & al. 2001). Photographs were taken with a DP72 camera attached to an Olympus SZX16 stereomicroscope and an Olympus BX61 compound microscope.

Taxon sampling for DNA analyses

Nuclear ITS1-5.8S-ITS2 rDNA sequences of twenty-five specimens representing ten species were used in the molecular study. Six new sequences were produced from specimens collected in China and nineteen sequences were downloaded from GenBank (Table 1). *Lobothallia alphoplaca*, *L. crassimarginata*, *L. helanensis*, *L. melanaspis*, *L. radiosa*, and *L. recedens* were used as outgroup.

Extractions, PCR amplifications, sequencing

Total genomic DNA was extracted from the samples using the SanPrep Column DNA Gel Extraction Kit following the manufacturer's instructions. The complete ITS region (ITS1-5.8S-ITS2) was amplified using the primer ITS1F (Gardes & Bruns 1993) combined with ITS4 or ITS5 combined with ITS4 (White & al. 1990). The PCR thermal cycling parameters were initial denaturation for 3 min at 94°C, followed by 35 cycles of 30 s at 94°C, 30 s at 52°C, 90 s at 72°C, and final elongation for 10 min at 72°C.

Amplification products were viewed on 0.8% agarose gels stained with ethidium bromide. The PCR amplicons were sequenced by Sangon Biotech Co. Ltd. with an ABI 3730 XL DNA Analyzer.

Sequence alignment & phylogenetic analyses

Sequences were assembled and edited using the program Geneious v6.1.2. Sequences were aligned using the program MAFFT v7 (Katoh & Toh 2008; Katoh & al. 2009). For ITS sequences, we used the L-ING-i alignment algorithm with the

Table 1. *Teuvoa* and *Lobothallia* species used in the phylogenetic analyses

Species	Locality	Voucher (Herbarium)	GenBank No.
T. alpina	China, Xinjiang	Li XL0306 (SDNU) [**T**]	**KX234706**
T. aff. *junipericola*	Iran	Sohrabi 9507B (hb. M. Sohrabi)	JX306740
T. junipericola	USA, Utah	Leavitt & Leavitt 850 (BRY–C54927)	JX306751
	USA, Utah	Leavitt & Felix 845 (BRY–C54926)	JX306750
	USA, Utah	St. Clair et al. 767 (BRY–C54923)	JX306747
	USA, Utah	St. Clair et al. 742 (BRY–C54922)	JX306744
	USA, Utah	Rosentreter 14521 (H) [**T**]	JX306741
T. saxicola	China, Qinghai	Ren 2722 (SDNU) [**T**]	**KX234703**
	China, Xinjiang	Ren 3352 (SDNU)	**KX234702**
T. tibetica	China, Xizang	Cheng 20116450 (SDNU)	**KX234705**
	China, Xizang	Cheng 20116469 (SDNU)	**KX234704**
	China, Qinghai	Ren 2730 (SDNU)	**KX234707**
	China, Xizang	Obermayer 04386 (H) [**T**]	GU289915
T. aff. *uxoris*	Turkey	Halici s.n. (hb. Halici)	JX306742
T. uxoris	Spain	Rico & Pizarro 3622B	JX306746
	Spain	Rico & Pizarro 3622 (H)	JX306743
	Spain	Rico & Pizarro 3622A	JX306745
L. alphoplaca	USA, Utah	Leavitt et al. 447 (BRY–C54921)	JX306737
	USA, Nevada	Leavitt & Leavitt 849 (BRY–C54920)	JX306739
L. crassimarginata	China, Nei Menggu	Wang 20122565 (SDNU)	JX476026
L. helanensis	China, Nei Menggu	Tong 20122791 (SDNU)	JX476031
L. melanaspis	Norway	Owe-Larsson 8943a	JF825524
	Sweden	Nordin 6622 (UPS)	HQ259272
L. radiosa	Sweden	Nordin 5889 (UPS)	JF703124
L. recedens	Sweden	Nordin 6035 (UPS)	HQ406807

Ex-type sequences are indicated by [**T**]. Newly obtained sequences are in **bold.**

remaining parameters set to default values. The alignments were analyzed by maximum likelihood (ML) and a Bayesian (BI) Markov chain Monte Carlo approach (B\MCMC). ML analyses were conducted in RAxML v8.2.6 (Stamatakis 2014). Bayesian analysis was performed using the software MrBayes v3.2.3 (Huelsenbeck & Ronquist 2001). Nucleotide substitution models were selected using the Akaike Information Criterion in jModelTest v2.1.7 (Darriba & al. 2012). Two B\MCMC analyses of two parallel runs were carried out for 10,000,000 generations. Each run included four chains, and trees were sampled every 1000 generations. All model parameters were unlinked. After discarding the burn-in, the remaining 7500 trees of each run were pooled to calculate a 50% majority-rule consensus tree. The clades that received bootstrap support (bs) ≥70% under ML and posterior probabilities (pp) ≥ 0.95 were considered well supported (Hillis & Bull 1993). Phylogenetic trees were visualized using FigTree v1.4.2.

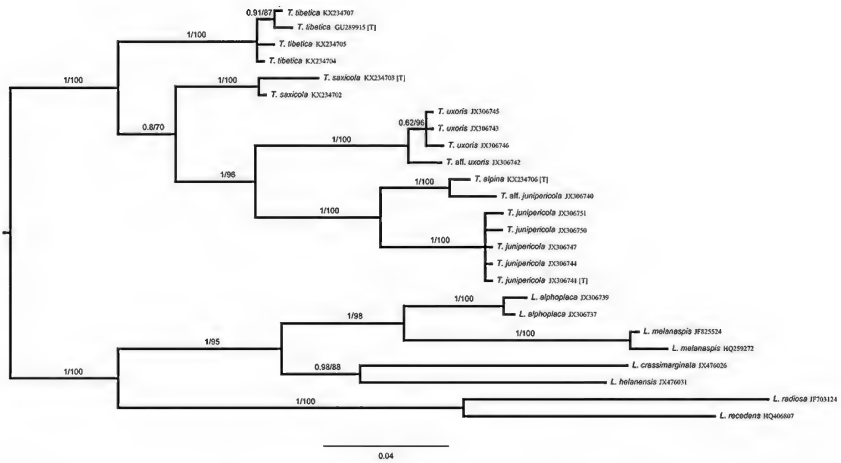

Fig. 1. Phylogenetic relationships within the genus *Teuvoa*, including the new species *T. saxicola* and *T. alpina*, with *Lobothallia* spp. outgroup. Phylogram inferred from Bayesian analysis of ITS dataset. Posterior probabilities ≥0.50 and ML bootstrap values ≥50% are indicated above internal branches. Ex-type sequences are annotated as [**T**].

Results & discussion

According to the results achieved from both analyses conducted with the ML with RAxML v8.2.6 and B\MCMC with MrBayes, we obtained congruent topologies; the BI topology is shown here (Fig. 1). In our phylogenetic trees, the *Teuvoa* representatives formed a strongly supported group sister to the *Lobothallia* representatives, further supporting segregation of *Teuvoa. Teuvoa* is divided into four well-supported clades, and the new species *T. saxicola* forms a highly supported clade (bs = 100%, pp = 1) within *Teuvoa.* The *Teuvoa junipericola* s.lat. lineage, strongly supported (bs = 96%, pp = 1) as sister to *T. uxoris,* is divided into two well supported clades, *T. junipericola* s.str. from western USA and *T. alpina* from northwestern China + *T.* aff. *junipericola* from Iran.

Taxonomy

Teuvoa saxicola Q. Ren, **sp. nov.** Fig. 2

Fungal Name FN570544

Differs from other *Teuvoa* species by its saxicolous habitat, and its yellow brown, thick thallus.

Type: China. Qinghai: Qilian Co., Yeniu Gou Town, Qilian mountain pass, 38°35.55′N 99°29.19′E, 4060 m, on siliceous rock, 21 Jun. 2013, Q. Ren 2722 (**Holotype**, SDNU; **isotype**, HMAS-L; GenBank KX234703).

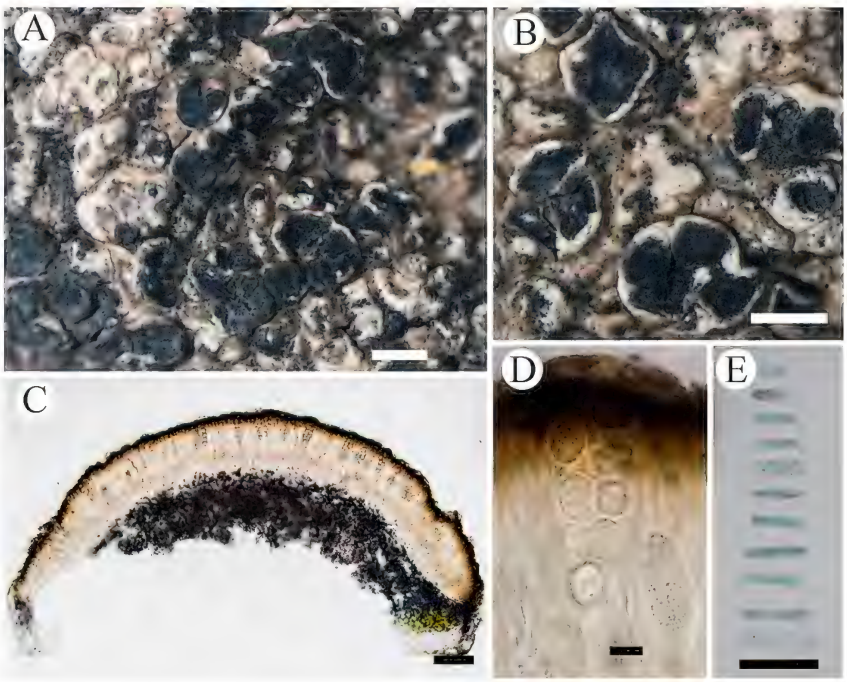

Fig. 2. *Teuvoa saxicola* (holotye, SDNU Ren 2722). A. Thallus with substratum; B. Apothecia; C. Section of apothecium; D. Ascus and ascospores; E. Conidia. Scale bars: A, B = 1 mm; C = 100 μm; D, E = 10 μm.

Etymology: The specific epithet refers to the substratum (siliceous rock) on which this new species grows.

Thallus saxicolous, crustose, continuous, rimose to areolate, sometimes verrucose, ≤3.5 mm thick. Areoles mostly irregular, sometimes angular to rounded, flat to convex, (0.25–)0.6–2 mm diam. Surface ochre to yellow brown, with a greenish tinge at the some parts of the thallus, slightly pruinose.

Apothecia numerous, one to several per areole, simple or composite, orbicular to slightly angular, 0.5–1.75 mm diam. Discs concave to plane, black, slightly pruinose. Thalline margin mostly prominent, elevated, sometimes indistinct, usually forming a black rim around the disc. Exciple ≤150 μm wide laterally, highly variable in development and thickness. Epihymenium dark brown, pigment N+ green, K+ brown. Hymenium hyaline, I+ persistently blue, 87.5–125 μm high. Subhymenium and hypothecium hyaline, I+ persistently blue, 25–37.5(–50) μm high. Paraphyses moniliform, with 3–7 globose to

subglobose cells apically. Asci clavate, *Aspicilia*-type, 8-spored. Ascospores hyaline, simple, globose or subglobose to ellipsoidal, 10–15 × 7.5–12.5 µm.

Pycnidia rare, immersed, rounded, with black ostioles. Conidia bacilliform, straight, 5–7.5(–10) × 0.7 µm.

Chemistry—Cortex and medulla K–, C–, KC–, I–. No secondary lichen substances detected by TLC.

Distribution & ecology—*Teuvoa saxicola* is known from Qinghai and Xinjiang provinces in northwestern China. It grows on siliceous rock in arid and semi-arid habitats.

Additional specimen examined—**CHINA. Xinjiang: Urumqi city,** Mt. Tianshan, Glacier No.1, 43°06.47′N 86°50.32′E, 3560 m, 8 Sept. 2013, Q. Ren 3352 (SDNU; Genbank KX234702).

Comments—The phylogenetic tree (Fig. 1) supports the two saxicolous specimens within a single well-supported lineage within *Teuvoa*. *Teuvoa saxicola* differs from other *Teuvoa* species by its saxicolous habitat, ochre or yellow brown thallus colour, and thick thallus. *Teuvoa tibetica* is a terricolous species with a white to whitish gray thallus and rhizomorph-like extensions. Both *T. uxoris* and *T. junipericola* are epiphytic species with a white to grey thallus (Sohrabi & al. 2013).

Teuvoa alpina Q. Ren, **sp. nov.** Fig.3

Fungal Name FN570545

Differs from *Teuvoa junipericola* s.str. by its smaller ascospores, and its higher altitude habitat.

Type: China. Xinjiang: Hami City, Baishitou, 2800 m, on coniferous wood, 28 Jul. 2013, Li XL0306 (**Holotype**, SDNU; **isotype**, HMAS-L; Genbank KX234706).

Etymology: The specific epithet refers to the high altitude at which this species grows.

Thallus epiphytic, crustose, continuous, rimose to areolate. Areoles mostly irregular, sometimes angular to rounded, flat to convex, 0.5–2.5 mm diam. Surface white to whitish grey with a greenish hue, smooth or slightly roughened, ± pruinose.

Apothecia numerous, cryptolecanorine or urceolate when young, becoming lecanoroid or lecideoid when mature, one to several per areole, simple or composite, orbicular to slightly angular, 0.5–2.0 mm diam. Discs concave to plane to slightly convex, brownish black to black, but appearing whitish to bluish grey due to pruina. Thalline margin mostly distinct, concolorous with thallus, thin, usually forming a white rim around the disc. Exciple highly variable in development and thickness, I+ blue. Epihymenium dark brown, pigment N+ green, K+ brown. Hymenium hyaline, I+ persistently blue, (75–)87.5–100 µm

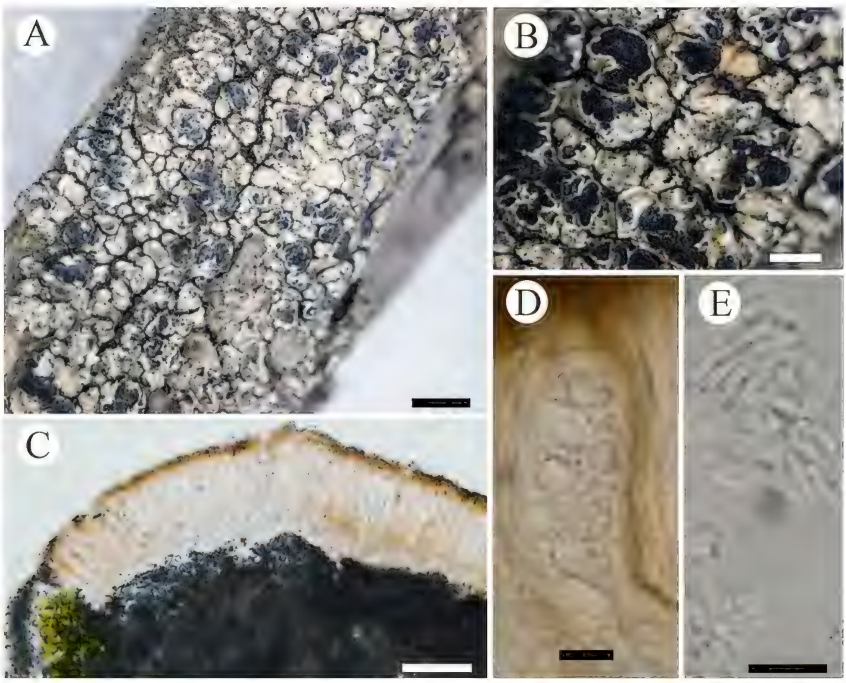

FIG. 3. *Teuvoa alpina* (holotye, SDNU Li XL0306). A. Thallus with substratum; B. Apothecia; C. Section of apothecium; D. Ascus and ascospores; E. Conidia. Scale bars: A = 2 mm; B = 1 mm; C = 100 μm; D, E = 10 μm.

high. Subhymenium and hypothecium pale, I+ persistently blue. Paraphyses submoniliform to moniliform, with 2–4 globose to subglobose cells apically. Asci clavate, *Aspicilia*-type, 8-spored. Ascospores hyaline, simple, ellipsoidal to subglobose, 10–15 × 7–10 μm. Pycnidia common, immersed, rounded, with black ostioles. Conidia bacilliform, straight, 5–7.5 × 0.7 μm.

CHEMISTRY—Cortex and medulla K–, C–, KC–, I–. No secondary lichen substances detected by TLC.

DISTRIBUTION & ECOLOGY—*Teuvoa alpina* is known from Xinjiang and Qinghai in northwestern China. It grows on coniferous wood in arid and semi-arid habitats.

ADDITIONAL SPECIMENS EXAMINED—**CHINA. XINJIANG: Urumuqi City,** Mt. Tianshan, 2800 m, on coniferous wood, 29 July 1978, Wang 0103 (HMAS-L). **QINGHAI. Qilian Co.,** Mt. Niuxinshan, 3050–3400 m, on coniferous wood, 11 Aug. 2007, Wang 20071462-1, 20071496-1, 20071026-1 (SDNU); Du 20071601-3 (SDNU); Shi 20071620-2 (SDNU).

COMMENTS—Our phylogenetic tree (FIG. 1) includes *T. alpina* within a single well-supported lineage with *T.* aff. *junipericola* from Iran, which is sister to

T. junipericola from western USA (Sohrabi & al. 2013). As we did not examine the only specimen identified as *T.* aff. *junipericola* from Iran, we do not treat the Iranian material here. *Teuvoa alpina* closely resembles *T. junipericola* from western USA in general appearance, but *T. junipericola* has larger ascospores (13–22 × 10–16 µm) and occurs at lower altitudes (1700–2100 m; Sohrabi & al. 2013).

Teuvoa tibetica (Sohrabi & Owe-Larss.) Sohrabi, Lichenologist 45: 357 (2013).

Sohrabi & al. (2010) characterize *T. tibetica* by a crustose, white to pale gray thallus, a lower surface with pale rhizomorph-like extensions, short conidia (5–7 µm), small ascospores (10–14 × 6–9 µm), *Aspicilia*-type 8-spored asci, a brown epihymenium, a short hymenium (70–80 µm), non-moniliform to submoniliform paraphyses, and the lack of secondary substances.

Specimens examined—**CHINA. Xizang: Anduo Co.,** Mt. Tanggula, 4700–5300 m, on soil or mosses, 31 Jul. 2011, Cheng 20116223, 20116236, 20116446, 20116469, 20116481, 20116482 (SDNU): Jiang 20116364 (SDNU). **Qinghai: Qilian Co.,** Yeniu Gou Town, Qilian Mountain Pass, 38°35.55′N 99°29.19′E, 4060 m, on mosses, 21 Jun. 2013, Q. Ren 2730 (SDNU).

Comments—Our new material closely matched the holotype description (Sohrabi & al. 2010). *Teuvoa tibetica* was previously known only from Xizang (four localities) and Sichuan (one locality) in China; we have added records from a third province, Qinghai, and an additional locality in Xizang.

Teuvoa tibetica generally resembles *Megaspora verrucosa* (Ach.) Hafellner & V. Wirth, which differs by its usually concave discs and much larger ascospores (35–50 × 25–39 µm) with thicker spore walls (c. 1.5–2.5 µm; James & Fletcher 2009).

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New records of *Lepraria* and *Pyrenula* from China

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Abstract—As a result of our study, two species of *Lepraria* (*L. atlantica*, *L. lobata*) and two species of *Pyrenula* (*P. duplicans*, *P. subelliptica*) are reported for the first time from China, and *Pyrenula pyrenuloides* is reported for the first time from Guizhou province.

Key words—Asia, lichen-forming fungi, taxonomy

Introduction

Lepraria Ach. (*Stereocaulaceae, Ascomycota*), a genus with a worldwide distribution, comprises morphologically simple lichen-forming fungi that never develop fruiting bodies (Orange 2001). Most species have a leprose, sterile thallus with a surface composed of granules. *Lepraria* taxonomy is largely based on the chemistry of secondary metabolites as these lichens produce a wide variety of lichen substances, and other characters are often scarce (Saag & al. 2009). A combination of morphological, chemical, and ITS and mtSSU sequence analyses have been used to investigate this genus (Lendemer & Hodkinson 2013). Also, Lendemer (2011) introduced a standardized morphological terminology and descriptive scheme that should facilitate specimen identification and description preparation.

Pyrenula Ach. (*Pyrenulaceae, Ascomycota*) comprises crustose lichens typically growing on smooth, shaded bark (Aptroot 2012). The

[#] Zhong-Liang Wang & Shu-Kun Yan contributed equally to this paper.

genus is characterized by perithecioid ascomata, occasionally inspersed hamathecia, unbranched filaments, and distoseptate or (sub)muriform brown mature ascospores. *Pyrenula* encompasses at least 211 species worldwide (Aptroot 2012; Aptroot & al. 2012, 2013, 2014, 2015; Aptroot & Common 2017; Cáceres & al. 2013; Lima & al. 2013; Mendonça & al. 2016; Wijeyaratne & al. 2012). The availability of a world key to the genus (Aptroot 2012) has made it much easier to recognize undescribed taxa.

The purpose of our study is to enrich knowledge of the species composition of *Lepraria* and *Pyrenula* in China, contributing fundamental data and reliable results for the preparation of a Lichen Flora of China. In this paper, we identify four species new to the country—*Lepraria atlantica*, *L. lobata*, *Pyrenula duplicans, P. subelliptica*—and report *P. pyrenuloides* for the first time from Guizhou province.

Materials & methods

The specimens studied are preserved in Lichen Section of Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). Morphological characters of the specimens were examined under a COIC XTL7045B2 stereomicroscope and an Olympus CX41 polarizing microscope and the lichens were photographed using Olympus SZX16 and BX61 microscopes with an Olympus DP72 digital camera. Sections were mounted in tap water (unless otherwise indicated), and all measurements were made in water or diluted KOH. Lichen substances were identified using standardized thin layer chromatography (TLC) techniques with system C (Orange & al. 2010).

Taxonomy

Lepraria atlantica Orange, Lichenologist 33: 462 (2001) Fig. 1a, b

Morphology—Thallus crustose, leprose (thalli continuous or sometimes diffuse), grey to pale whitish grey, consisting of loosely to densely packed granules, hyphae absent or very short (20–40 µm) in the marginal granules; prothallus absent; hypothallus present, usually forming a thin continuous layer underneath the granules; rhizohyphae absent. Granules globose, ecorticate, (40–)50–60(–80) µm diam., well organized and discrete, remaining distinct and forming compound units. Photobiont green, cells globose, 7.5–15 µm diam. Substrate bryophyte.

Chemistry—Thallus K+ yellow, C–, KC–, Pd+ yellow. Porphyrilic acid detected by TLC.

Specimens examined: **CHINA. Qinghai, Huzhubeishan National Forest Park**, Yaoshuiquan waterfall, alt. 2830m, on bryophyte, 19 Aug. 2007, Y.D. Du 20072234 (SDNU); 109 national highway, Xiangpishan, alt. 3520 m, on bryophyte , 15 Aug. 2007, Y.D. Du 20071952 (SDNU).

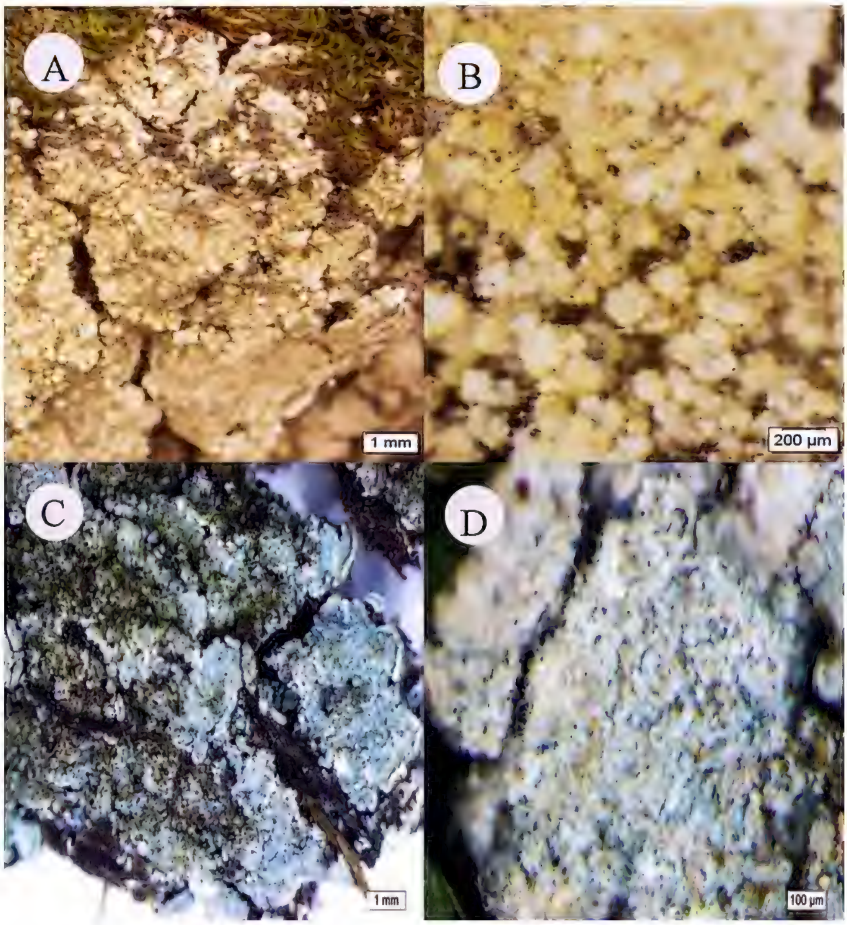

Fig. 1 ***Lepraria atlantica*** (20071952, SDNU). A: thallus; B: granules. ***Lepraria lobata*** (20160512, SDNU). C: thallus and margin; D: granules. Scale bars: A, C = 1 mm; B, D = 200 µm.

Distribution—Wales, the Scottish Highlands, Northwest Ireland, Norway, Australia, Greenland (Orange 2001, Saag & al. 2009, Smith & al. 2009). New to China.

Comments—*Lepraria atlantica* is chemically similar to *L. cacuminum*, which differs by its coarsely granular thallus (Orange 2001), and morphologically similar to *L. jackii*, which differs by not producing porphyrilic acid (Orange 2001, Saag & al. 2007). Our Chinese specimens closely match the protologue description (Orange 2001).

Lepraria lobata Elix & Kalb, Mycotaxon 94: 220 (2006) Fig. 1c, d

Morphology—Thallus crustose, leprose, placodioid, whitish grey to pale greenish grey, margin delimited, forming thin to thick ±continuous extensive irregularly spreading lobes; hyphae hyaline, 25–30 µm long, few surrounding the granules and anchoring the granules tightly to one another; prothallus absent; hypothallus present, usually forming a thin continuous layer underneath the granules; rhizohyphae rarely present. Granules globose, ecorticate, (20–)40–50(–70) µm diam., abundant. Photobiont green, cells globose, 7.5–12.5 µm in diam. Substrate bark.

Chemistry—Thallus K+ yellow, C–, KC+ yellow, Pd–. Atranorin, zeorin, and unknown fatty acid detected by TLC.

Specimens examined: **CHINA. Shandong Mt. Lushan**, Guanyunfeng, alt. 695m, on bryophyte, 25 Jun. 2016, X.X. Zhao 20160512 (SDNU); **Guizhou. Tongzi**, Mt. Shixizhenbaizhi, Dongwan to Tiedingba, alt. 2050m, on bark, 25 Jul. 2016, W.C. Wang 20160343 (SDNU).

Distribution—Australia, South Korea (Saag & al. 2009, Joshi & al. 2010). New to China.

Comments—*Lepraria lobata* is chemically similar to *L. pallida*, which is distinguished by a green thallus and gray to black hypothallus rather than rhizohyphae (Joshi & al. 2010). Our Chinese specimens closely agree with the protologue description, except that the holotype lacks a hypothallus (Saag & al. 2009).

Pyrenula duplicans (Nyl.) Aptroot, Biblioth Lichenol. 97: 102 (2008) Fig. 2a–c

Morphology—Thallus corticate, smooth, yellowish to olive green, with white pseudocyphellae. Perithecia mostly simple, only aggregated (as if by chance) when crowded, erumpent from the substratum, covered by thallus, 0.5–1.0 mm diam. Perithecial wall ≤200 µm thick. Ostiole pale, apical. Hamathecium not inspersed with oil droplets, filaments unbranched. Ascospores 2/ascus, grey brown, densely muriform with 9–11 primary septa, ellipsoid with rounded ends, 110–115 × 25–27.5 µm, lumina rounded to somewhat angular. Substrate bark.

Chemistry—No chemical substances detected by TLC.

Specimen examined: **CHINA. Guizhou, Jiangkou,** Guanhexiang, Leijiayan, alt. 850 m, on bark, 2 Apr. 2016, X.X. Zhao 20160698 (SDNU).

Distribution—Pantropical (Aptroot 2012). New to China.

Comments—*Pyrenula duplicans* is characterized by its thallus bearing white pseudocyphellae, apical ostiole, non-inspersed hamathecium, and large

muriform ascospores. Our Chinese specimen is similar to the protologue description, except that the holotype has longer (115–180 μm) ascospores (Aptroot 2012).

Pyrenula pyrenuloides (Mont.) R. C. Harris,
Mem. New York Bot. Gard. 49: 99 (1989) FIG. 2D–G

MORPHOLOGY—Thallus corticate, smooth, pale brownish to olive green, with white pseudocyphellae. Perithecia mostly simple, only aggregated as if by chance when crowded, subglobose, erumpent from the substratum, sides often partly covered by thallus, 0.5–0.9 mm diam. Perithecial wall with crystals, ≤200 μm thick. Ostiole pale, apical. Hamathecium not inspersed with oil droplets, filaments unbranched. Ascospores 8/ascus, grey brown, biseriate in the ascus, muriform with 7–10 rows of 3–8 locelli, fusiform with rounded ends, 50–55 × 12.5–17.5 μm, lumina rounded to somewhat angular. Substrate bark.

CHEMISTRY—No chemical substances detected by TLC.

SPECIMENS EXAMINED: **CHINA. GUIZHOU, Leishan,** Mt. Leigongshan, alt. 1160 m, on bark, 1 Nov. 2009, Q. Tian 20102751, 20102817, 20102945 (SDNU).

DISTRIBUTION —Pantropical (Aptroot 2012). New to Guizhou province, but previously reported from Hongkong (Aptroot & Seaward 1999).

COMMENTS—*Pyrenula pyrenuloides* is characterized by the thallus with white pseudocyphellae, apical ostiole, non-inspersed hamathecium, small muriform ascospores and the central part of the ascospore with more than six lumina between two primary septa. *Pyrenula pyrenuloides* is closely related to *P. papillifera*, but the latter has pointed ends ascospores (Aptroot 2012). Our Chinese specimens closely match the protologue description (Aptroot 2012).

Pyrenula subelliptica (Tuck.) R.C. Harris, Bryologist 90 : 164 (1987) FIG. 2H–K

MORPHOLOGY—Thallus corticate, whitish to pale brown, without pseudocyphellae. Perithecia solitary, subglobose, erumpent from the substratum, sides scarcely covered by thallus, 0.3–0.5 mm diam. Ostiole pale, apical. Hamathecium inspersed with hyaline oil globules, filaments unbranched. Ascospores 8/ascus, grey brown, 3-septate, fusiform with rounded ends, 30–35 × 10–12.5 μm, angular lumina in a straight line, terminal lumina separated from the exospore by an endospore layer, central lumina strongly elongated. Substrate bark.

CHEMISTRY—No chemical substances detected by TLC.

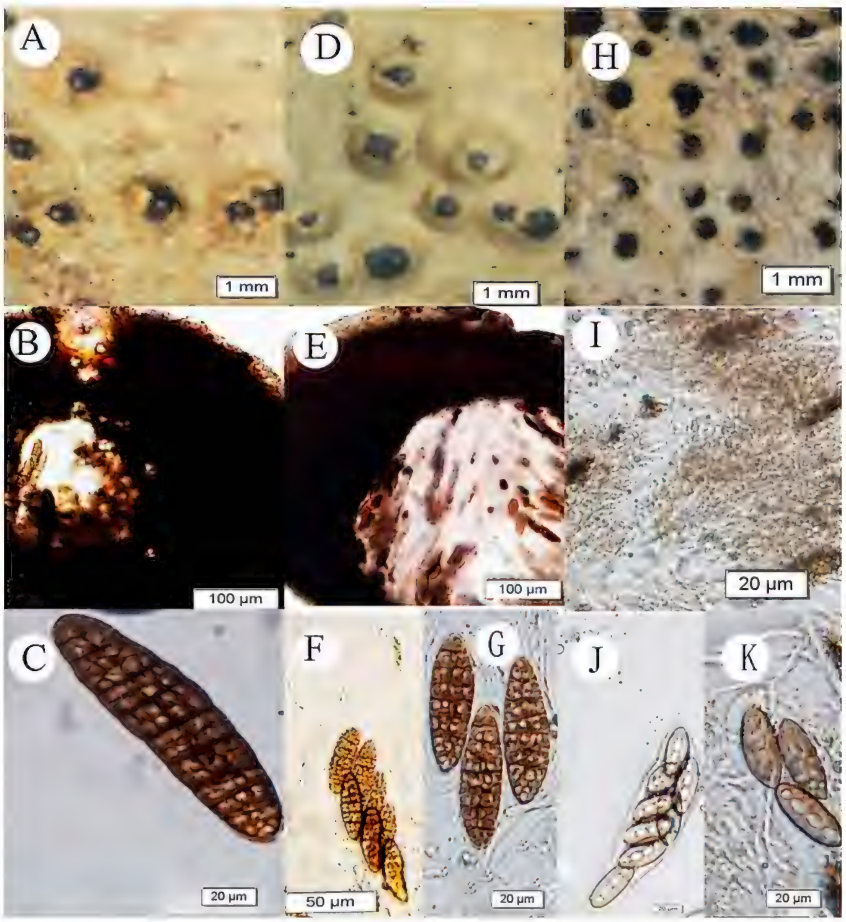

Fig. 2 ***Pyrenula duplicans*** (20160698, SDNU). A: thallus with ascomata; B: transverse section through ascoma; C: ascospore. ***Pyrenula pyrenuloides*** (20102817, SDNU). D: thallus with ascomata; E: transverse section through ascoma; F: ascus with ascospores; G: ascospores. ***Pyrenula subelliptica*** (20103054, SDNU). H: thallus with ascomata; I: inspersed hamathecium; J: ascus with 8 ascospores; K: ascospores. Scale bars: A, D, H = 1 mm; B, E = 100 µm; F = 50 µm; C, G, I – K = 20 µm.

Specimens examined: **CHINA. Guizhou, Leishan,** Mt. Leigongshan, alt. 2178 m, on bark, 1 Nov. 2009, Z.T. Zhao 20103054 (SDNU). Jiangxi, Jian, Qianmo village, alt. 1300 m, on bark, 1 Nov. 2010, D.F. Jiang 20106232 (SDNU).

Distribution—India, North America, Russia (Jagadeesh & Sinha 2010, Harris 1989, Urbanavichene & Urbanavichus 2016). New to China.

Comments—*Pyrenula subelliptica* is characterized by the apical ostiole, inspersed hamathecium, distoseptate ascospores with three septa, terminal lumina separated from the exospore by an endospore layer, and strongly elongated central lumina. Our Chinese specimens are closely similar to the protologue description, except that the holotype has a non-inspersed hamathecium (Jagadeesh & Sinha 2010).

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Ellisembia hainanensis sp. nov. from Hainan, China

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Abstract—*Ellisembia hainanensis*, isolated from decaying dicotyledonous leaves from Wuzhi Mountain, Hainan Province, is described and illustrated as a new species. The fungus is characterized by obclavate 9–11-septate brown conidia, with the hyaline apical and first subapical cells surrounded by a mucilaginous sheath. A comparative table of the morphology of similar *Ellisembia* species is provided.

Key words—fungal diversity, morphology, aquatic hyphomycetes

Introduction

The genus *Ellisembia* was introduced by Subramanian to accommodate *Sporidesmium*-like species, with *Sporidesmium coronatum* Fuckel [≡ *Embellisia coronata* (Fuckel) Subram.] as type species (Subramanian 1992). Several *Ellisembia* species have been described from China (Shi & Zhang 2007; Ma & Zhang 2007; Ma & al. 2008, 2011a,b; Ren & al. 2013; Xia & al. 2015, 2016; Wu & Zhuang 2005), and the taxonomic history of the genus has been reviewed in related papers. China has an enormous diversity of fungi occurring on dead branches and rotten submerged wood and leaves, especially Hainan Province with its 22–26°C annual average temperature. Previously, six *Ellisembia* species have been isolated from Hainan Province (Ma & al. 2008, 2011a; Ren & al. 2013; Qiao & al. 2018).

During a study of aquatic hyphomycetes in Wuzhi Mountain Preserve, Hainan Province, China, we encountered an unknown fungus that shared some features of *Ellisembia*; we describe it here as a new species, *E. hainanensis*.

Materials & methods

The culture was isolated in June 2011 from decaying leaves of a broadleaf tree in the Wuzhi Mountain Preserve, Hainan province, southern China. The leaves were cut into several 2–4 × 2–4 cm fragments, which were laid out on the surface of CMA (20 g cornmeal, 18 g agar, 40 mg streptomycin, 30 mg ampicillin, 1000 ml distilled water) for ten days; single conidia were captured with a sterilized toothpick while viewing with a CX31 microscope and cultivated on CMA in Petri plates. We observed the morphology after incubation at 28°C on CMA for one week. The pure cultures and a permanent slide were deposited in the Herbarium of the Laboratory for Conservation and Utilization of Bio-resources, Yunnan University, Kunming, P.R. China (YMF) [formerly Key Laboratory of Industrial Microbiology and Fermentation Technology of Yunnan].

Taxonomy

Ellisembia hainanensis M. Qiao & Z.F. Yu, **sp. nov.** PLATE 1

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Differs from *Ellisembia minigelatinosa* by longer conidia and fewer hyaline subapical cells covered by a mucilaginous sheath.

TYPE: China, Hainan, Wuzhi Mountain Preserve, 18°38′N 109°19′E, elev. 1267 m, on decaying leaves of a broadleaf tree, June 2011, coll. Ze Fen Yu. (**Holotype**, YMF 1.040416 [permanent slide]; ex-type culture, YMF1.04041).

ETYMOLOGY: Latin, *hainanensis* referring to the province in which the species was found.

COLONIES 2.5 cm diam. on CMA after 10 days. Mycelium partly superficial, partly immersed. CONIDIOPHORES macronematous, mononematous, erect, straight, base enlarged to subspherical or L-shaped, 16–32 × 3.5–4 µm, smooth, 1–3-septate. CONIDIOGENOUS CELLS monoblastic, integrated, terminal, cylindrical or lageniform, 9–11 × 3–4 µm. CONIDIA solitary, acrogenous, obclavate, truncate at the base, tapering to the fifth septa, brown, with the apical and first subapical cells hyaline and surrounded by a mucilaginous sheath, 9–11-distoseptate, mostly 10-septate, 45–63 × 8.0–13.5 µm, diameters 1.5–2.6 µm at the apex and 1.8–2.8 µm at the base.

Discussion

Among known species of *Ellisembia*, more than 10 species possess a mucilaginous sheath at the tip of conidia (McKenzie & al. 1995). Among them, six species are similar to *E. hainanensis* in the number of septa and conidial shape, but there are obvious differences among them. Conidiophores of six species are longer than those of *E. hainanensis,* which is distinguished from all six species by the combination of conidial septa number and size

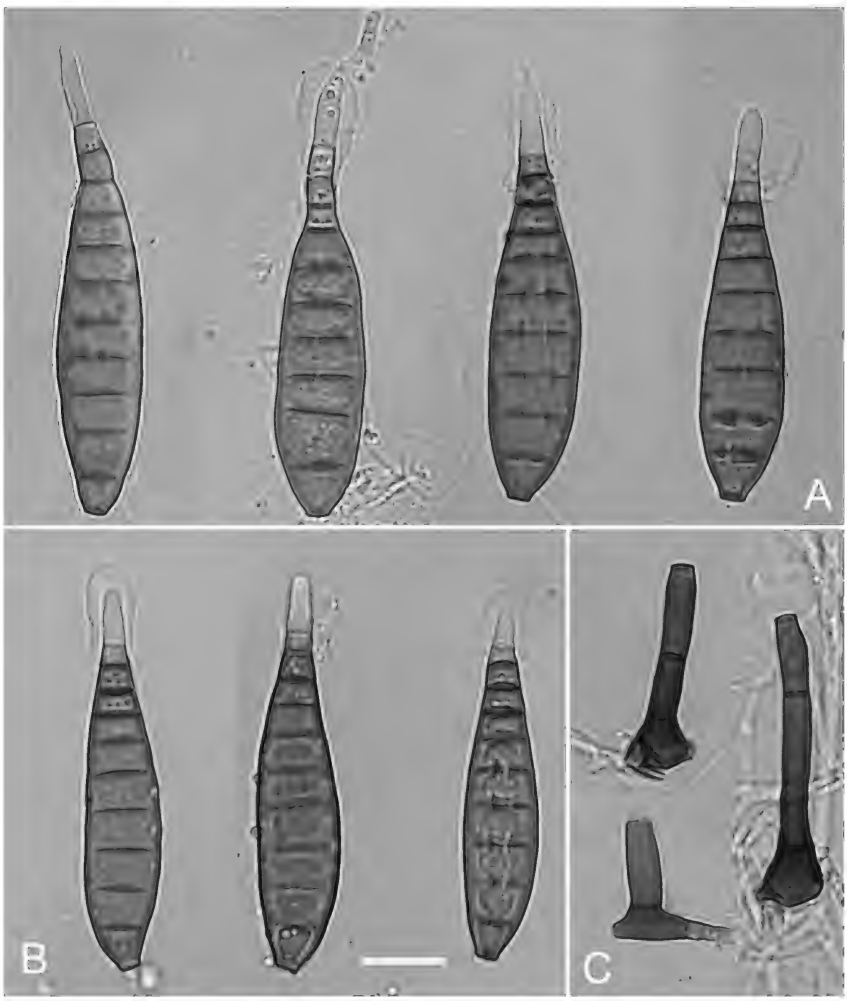

Plate 1. *Ellisembia hainanensis* (holotype, YMF 1.40416)
A, B. Conidia; C. Conidiophores and conidiogenous cells. Scale bars = 10 μm.

(Table 1). *Embellisia antillana* (R.F. Castañeda & W.B. Kendr.) McKenzie and *E. globulosa* W.P. Wu differ in their wider conidia, while *E. guangdongensis* W.P. Wu produces longer and narrower conidia than *E. hainanensis*. The conidia of *E. vaginata* McKenzie are smaller and have more variable septation than those of *E. hainanensis*. *Embellisia minigelatinosa* (Matsush) W.P. Wu,

Table 1. Morphological comparison of *Ellisembia hainanensis* and similar species

Species	Conidiophore length (μm)	# septa	Conidia L × W (μm)	Reference
E. antillana	50–80	7–11	60–75 × 16–20	Wu & Zhuang (2005)
E. globulosa	110–130	8–11	50–64 × 17–18	Wu & Zhuang (2005)
E. guangdongensis	110–130	8–10	58–77 × 8–9	Wu & Zhuang (2005)
E. hainanensis	**16–32**	**9–11**	**45–63 × 8–13**	**This paper**
E. minigelatinosa	40–100	9–11	42–52 × 8–12	Wu & Zhuang (2005)
E. paravaginata	55–85	10–12	55–70 × 12–14.5	McKenzie (1995)
E. vaginata	30–60	7–11	30–50 × 7–11	McKenzie (1995)

which is the species most similar to *E. hainanensis* in conidial septation and size, is distinguished by the presence of four hyaline subapical cells; moreover, in *E. minigelatinosa* the conidia are widest the second or third septa (vs. the third and fifth septa in *E. hainanensis*.

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New records of *Arthoniaceae* from Vietnam

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Abstract—*Arthonia complanata*, *A. elegans*, *A. pyrrhuliza*, *Arthothelium ruanum*, *A. spectabile*, and *Herpothallon minimum* are newly reported from Vietnam. An identification key is provided to the 18 *Arthoniaceae* species known from Vietnam.

Key words—corticolous, lichenized fungi, mangrove, national park, taxonomy

Introduction

The present study was conducted at low (<300 m) elevations of southern Vietnam in two national parks: Nam Cat Tien National Park and Dan Xay Mangrove Park. In addition to several interesting elements in *Graphidaceae*, *Pyrenulaceae*, and *Trypetheliaceae*, the national parks revealed the significant occurrence of arthonioid lichens. The *Arthoniaceae* have been little studied in Vietnam: Aptroot & Sparrius (2006) catalogued seven species, *Arthonia antillarum* (Fée) Nyl., *A. cinnabarina* (DC.)Wallr., *A. cyanea* Müll. Arg., *A. microcephala* Vězda, *Crypthonia mycelioides* (Vain.) Frisch & G. Thor, *Herpothallon rubrocinctum* (Ehrenb.) Aptroot & al., and *Myriostigma candidum* Kremp., together with some doubtful species records. Nguyen & al. (2011) recorded *Arthonia accolens* Stirt., while Joshi & al. (2014, 2015) added *Arthonia diorygmatis* S. Joshi & Upreti, *A. excipienda* (Nyl.) Leight., *A. radiata* (Pers.) Ach., and *Herpothallon sipmanii* Aptroot & al.

Our study presents six new Vietnamese records of corticolous lichenized fungi representing *Arthonia*, *Arthothelium*, and *Herpothallon*. An identification key to the *Arthoniaceae* species known from Vietnam is included.

Materials & methods

Lichen specimens collected in December 2015 were deposited in Korea National Arboretum (KH), Pocheon, South Korea in 2016, and samples were studied in the Lichenology laboratory of CSIR-National Botanical Research Institute, Lucknow, India. The morphology was examined using a MSZ-TR dissecting microscope and a Leica DM 500 compound microscope. The following literature was consulted for the identifications: Willey 1890; Awasthi 1991; Makhija & Patwardhan 1995; Aptroot & Sparrius 2006; Grube 2007; Aptroot & al. 2009; Smith & al. 2009; Bungartz & al. 2013; Frisch & Thor 2010; Nguyen & al. 2011; Joshi & al. 2013, 2014, 2015; Jagadeesh Ram & Sinha 2016; Lee & Hur 2016. Thin layer chromatography (TLC) in solvent system A was performed following Orange & al. (2010). Lugol's solution was used to check amyloidity (I+ or I–). Illustrations were prepared using Corel Draw (ver. 12).

Taxonomy

Arthonia complanata Fée, Essai Crypt. Exot.: 54, 1825 ["1824"]. Pl. 1a

Thallus epiperidermal, pale green to off-white, evanescent, delimited by brownish black prothallus, 50–80 µm thick; photobiont trentepohlioid; medulla partly immersed, white; ascomata immersed to emergent, round, shortly linear, flat to convex, black, epruinose, 0.5–1 × 0.3–0.6 mm; epihymenium brownish, K+ greenish, 10–15 µm high; hymenium hyaline to yellowish, filled with a gel matrix, 80–90 µm high, I+ blue; hypothecium hyaline to yellowish, 20–25 µm; asci 8-spored, 70–80 × 25–30 µm, I+ wine red; ascospores soleiform, hyaline, soon becoming brown, transversely 3–4-septate, with large, undivided upper and lower cells, 20–28 × 7–11 µm, I–.

Chemistry—No chemicals detected with TLC.

Distribution & ecology—This species has a tropical distribution (Willey 1890). In Vietnam, *A. complanata* was growing in small and irregular patches on thick and smooth barked trees in association with *Arthothelium* spp.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°24′20″N 107°17′19″E, alt. 256 m, on bark, 17 December 2015, Hur & Woo VN150021 (KH).

Remarks—Enlarged cells at both the ends of ascospores are characteristic of *Arthonia complanata* and distinguish it from *Arthonia excedens* Nyl., which also differs in producing larger ascospores (30–36 × 10–15 µm; Willey 1890, Lee & Hur 2016). Initially, the Vietnamese sample was wrongly interpreted

as *Arthonia ilicinella* Nyl. based on the smaller ascospore size (18–23 × 7–9 µm) cited in the Smith & al. (2009) description. Subsequent comparison of our sample with the description of *A. ilicinella* provided by Nylander (1867) indicated that the *A. ilicinella* ascospores were larger (21–36 × 8–12 µm).

Arthonia elegans (Ach.) Almq.,
Kongl. Svenska Vetensk. Acad. Handl., n.s., 17(6): 19, 1880. Pl. 1B

Thallus mostly endoperidermal reflecting bark texture, whitish to pale green delimited by dark brown prothallus, 50–80 µm thick; photobiont trentepohlioid; medulla endoperidermal; ascomata linear, irregularly to stellately branched, reddish black, epruinose to reddish brown pruinose near the margins, 1–2 × 0.1–0.2 mm; epihymenium reddish brown, K+ purple-red, 5–10 µm high; hymenium hyaline or pale yellow-reddish with anastomosed paraphysoids in a gel matrix, 25–50 µm high, I+ bluish; hypothecium pale yellow-reddish to brownish, 20–25 µm high; ascus 8-spored, 20–25 × 10–15 µm, I+ bluish; ascospores hyaline, soleiform, transversely 4–5-septate with upper enlarged cell, 10–12 × 3–5 µm, I–.

Chemistry—No lichen substances detected with TLC.

Distribution & ecology—Previously known from temperate Europe (Acharius 1810). In Vietnam, it was collected from smooth barked trees.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°26′40″N 107°24′23″E, alt. 164 m, on bark, 18 December 2015, Hur & Woo VN150264 (KH).

Remarks—*Arthonia elegans,* which is in need of urgent taxonomic revision, has been treated under different concepts by various authors. Acharius (1810) did not provide spore sizes in his type description of *Spiloma elegans*. Almquist (1880) reported 15–18 × 7–8 µm spores (3-septate only), 45 × 22 µm asci, and ochre pruinose ascomata, while Smith & al. (2009) described a different taxon (*A. elegans* sensu auct. brit., non (Ach.) Almq.), citing 14–19 × 4.5–7 µm spores (2–5-septate). Although our Vietnamese specimen has even smaller asci and ascospores, it may be either referred to a very broad concept of *Arthonia elegans* s.l. (with a wide range of ascospore sizes, 10–19 × 3–8 µm) or represent an unnamed new species.

Arthonia pyrrhuliza Nyl., Flora 68: 447, 1885. Pl. 1C

Thallus epiperidermal, whitish grey to off-white, ± rimose, delimited by brownish prothallus, 70–150 µm thick; photobiont trentepohlioid; medulla epiperidermal, white, crystalline; ascomata shortly lirellate, linear to bi- or trifurcate, cracked near margins, reddish brown to brown, 0.5–1 × 0.02–0.05

mm, the decaying or infected discs appear dark brown to black; epihymenium brownish, K+ greenish, 15–20 µm high; hymenium hyaline to yellowish, clear, with anastomosed paraphysoids in a gel matrix, 70–80 µm high, I+ blue; hypothecium indistinct; asci broadly clavate, 8-spored, 60–75 × 30–32 µm, I+ wine red; ascospores hyaline, soleiform, with undivided upper cell, tapering at one end, transversely 4-septate, 30–35 × 10–12 µm, I–.

Chemistry—No chemicals detected with TLC.

Distribution & ecology—This maritime species was previously recorded from North America (Grube 2007). In Vietnam, *A. pyrrhuliza* was collected from mangrove forests on thin and ± rough barked trees, where it was growing together with *A. antillarum*.

Specimens examined: **VIETNAM. Ho Chi Minh City: Can Gio district**, Dan Xay Mangrove Park, alt. 13 m, 10°27′35″N 106°54′16″E, on bark, 21 February 2015, Hur & Woo VN150416, VN150417, VN150418, VN150419B, VN150420, VN150426, VN150427, VN150429, VN150436, VN150439 (KH).

Remarks—Superficially, the species can wrongly be interpreted as *Enterographa* spp., which however has entirely different apothecial anatomy. *Arthonia pyrrhuliza* ascospores have been recorded as 12–15 × 4.5 µm (Willey 1890) and 13–19 × 5–7 µm (Grube 2007); however, Vietnamese material differs in producing significantly larger ascospores, appearing much closer in morphology and ascospore size (25–43 × 10–15 µm) to *Arthonia rubella* (Fée) Nyl., which is otherwise distinguished by its ascospores with undivided and rarely tapered large cells at both ends (Willey 1890; Brodo & al. 2001). Given the contradiction with previous descriptions, it is also possible that our material represents an undescribed species. At this time we choose to refer our Vietnamese specimens to *A. pyrrhuliza,* noting that most parts were infected with some lichenicolous fungus producing a black powdery mass.

Arthothelium ruanum (A. Massal.) Körb., Parerga Lichenol. 3: 263, 1861. Pl. 1D

Thallus endoperidermal, thin, brownish grey to off-white, delimited by dark brown to blackish prothallus, ≤50 µm thick; photobiont trentepohlioid, layer poorly developed, mostly dispersed; medulla indistinct to endoperidermal; ascomata scattered to aggregated, numerous, immersed, irregular to bluntly stellate, brownish black, epruinose, sometimes covered marginally with thalline layer, 0.5–1 mm in diam.; epihymenium dark brown, K+ greenish, 10–15 µm high; hymenium hyaline to brownish, clear, with adglutinate paraphysoids, 50–60 µm high, I+ bluish; hypothecium brown, 20–25 µm high; asci 8-spored, 30–50 × 15–20 µm, I+ wine red; ascospores hyaline, muriform (10–15 transverse septa and 2–4 longitudinal septa), 20–25 × 7–10 µm, I–.

Chemistry—No lichen substances detected in TLC.

Distribution & ecology—*Arthothelium ruanum* occurs in Europe, North America, and Asia (Smith & al. 2009, Joshi & al. 2013). In Vietnam, it was collected from thin- and smooth-barked trees.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°25′19″N 107°25′41″E, alt. 135 m, on bark, 18 December 2015, Hur & Woo VN150290 (KH).

Remarks—*Arthothelium ruanum* has also been treated under *Arthonia* as *A. ruana* A. Massal., following incessant discussions and arguments regarding the diagnostic importance of spore septation. Generic delimitation between *Arthonia* and *Arthothelium* is for the most part based on ascomal development (stromatic vs. solitary), epithecium (persistent vs. eroding), arrangement (loose vs. dense) of interascal filaments, and synchronous vs. irregular ascal development (Coppins & James 1979, Grube & Giralt 1996, Lee & Hur 2016). Until there are more extensive studies and wide acceptance of this generic delimitation, we cautiously refer our Vietnamese specimen to *Arthothelium*.

Arthothelium spectabile A. Massal., Ric. Auton. Lich. Crost.: 54, 1852. Pl. 1e

Thallus endoperidermal, whitish grey to dull grey, delimited by blackish prothallus, 100–170 µm thick, photobiont trentepohlioid, layer distinct, continuous, 60–80 µm thick; medulla endoperidermal; ascomata scattered, immersed, roundish, irregular to shortly elongate, ± flat, black, epruinose, flaking away from the thallus at maturity, 0.5–1 × 0.3–0.5 mm; epihymenium brownish green, K+ greenish, 10–15 µm high; hymenium ± hyaline, inspersed with oil droplets, 80–100 µm high, I+ blue; hypothecium hyaline to yellowish, 20–25 µm high; asci 8-spored, 50–80 × 45–50 µm, I + bluish; ascospores hyaline to brownish in late maturity, muriform (10–15 transverse septa and 2–4 longitudinal septa), 35–40 × 10–15 µm, I–.

Chemistry—No lichen substances detected with TLC.

Distribution & ecology—Cosmopolitan (Makhija & Patwardhan 1995; Smith & al. 2009). In Vietnam, *A. spectabile* was growing luxuriantly in mangrove forests and collected from thick and rough barked trees.

Specimens examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°24′20″N 107°17′19″E, alt. 256 m, on bark, 17 December 2015, Hur & Woo VN150070 (KH); Yak farm, 11°23′10″N 107°21′46″E, alt. 128 m, on bark, 17 December 2015, Hur & Woo VN150149 (KH).

Remarks—The Vietnamese specimens agree well with previous descriptions of *A. spectabile* and differ from the closely related *A. keralense* Makhija & Patw., which has a thicker algal layer (50–150 µm; Makhija & Patwardhan 1995).

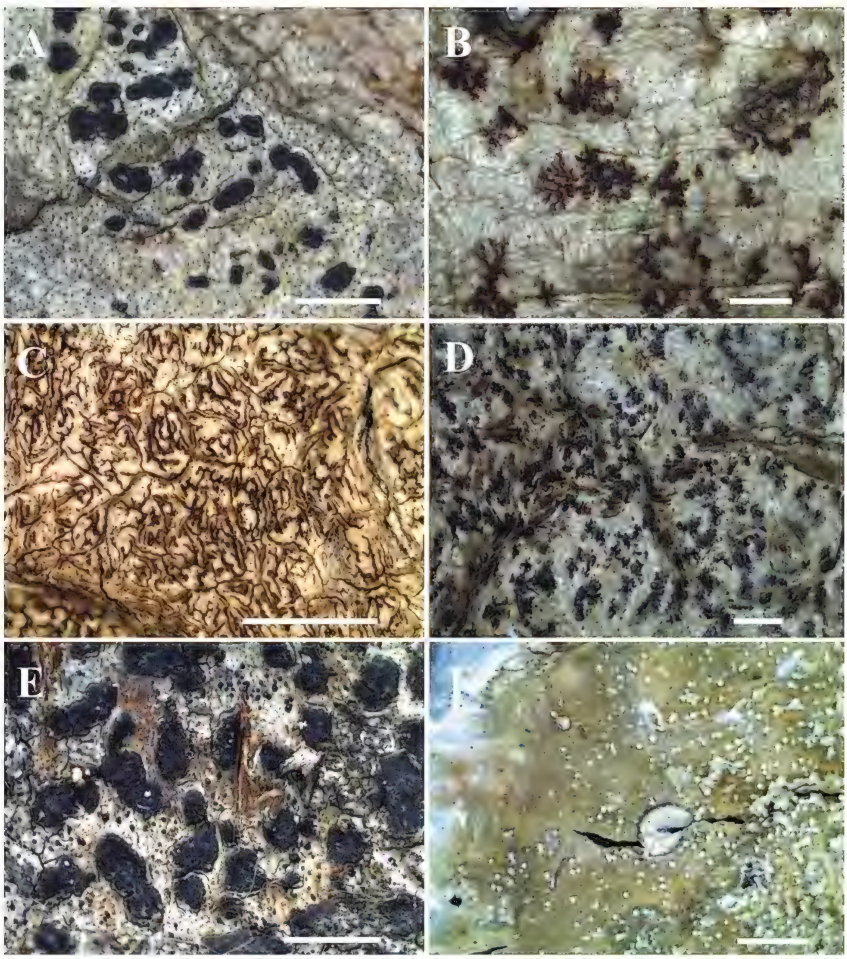

Plate. 1. Arthoniaceous species newly recorded from Vietnam. A. *Arthonia complanata*; B. *Arthonia elegans*; C. *Arthonia pyrrhuliza*; D. *Arthothelium ruanum*; E. *Arthothelium spectabile*; F. *Herpothallon minimum*. Scale bars = 1 mm.

Herpothallon minimum Aptroot & Lücking, Biblioth. Lichenol. 99: 53, 2009. Pl. 1F

Thallus epiperidermal, off-white, pale greenish grey or mineral-grey, ecorticate, sterile, resting on white, byssoid hypothallus, closely adpressed to the substrate, delimited by a broad prothallus of loosely radiating fibrous strands of white hyphae, ≤150 µm thick; abundantly covered with irregular to cylindrical pseudoisidia, ≤0.05 mm long and wide, loose-byssoid, irregular, whitish hypothallus; pycnidia present at the tip of pseudoisidia as black dots.

Chemistry—2′-O-methylperlatolic acid detected with TLC.

Distribution & ecology—Recorded from America and Africa (Aptroot & al. 2009). In Vietnam, *H. minimum* was luxuriantly colonized under shaded trees of seasonal forests in the low-land humid climate of the national park.

Specimens examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, 11°26′43″N 107°24′21″E, alt. 166 m, on bark, 18 December 2015, Hur & Woo VN150269 (KH); 11°26′32″N 107°24′55″E, alt. 151 m, on bark, 19 December 2015, Hur & Woo VN150346, VN150349 (KH); 11°26′60″N 107°21′48″E, alt. 163 m, on bark, 19 December 2015, Hur & Woo VN150395 (KH).

Remarks—The Vietnamese specimens agree well with the type description of *Herpothallon minimum* (Aptroot & al. 2009), but the Vietnamese specimens were initially incorrectly accommodated under *H. granulare* (Sipman) Aptroot & Lücking as a result of their pseudoisidia being misinterpreted as soredia-like granules.

Key to species in *Arthoniaceae* recorded from Vietnam

1. Thallus absent, lichenicolous on *Diorygma*; ascomata dot-like, round, irregular to shortly lirellate, prominent; epihymenium K+ purple, hymenium inspersed (with oil droplets); ascospores hyaline becoming dark brown and warty, 1-septate, 10–16 × 4–5 µm ..... ***Arthonia diorygmatis***
1. Thallus present, non-lichenicolous 2
2. Thallus fertile, byssoid or crustose, ascigerous area organized or not 3
2. Thallus sterile, byssoid, leprose, pseudoisidia present, hypothallus distinct; prothallus made up of radiating hyphae 15
3. Thallus foliicolous or corticolous, byssoid, ecorticate, ascigerous area unorganized, asci closely aggregated in distinctly raised, maculate, flat, ± rounded structures; ascospores muriform, 45–65 × 15–25 µm; 2′-O-methylanziaic and 2′-O-methylperlatolic acids present; hymenium clear or inspersed ..... ***Myriostigma candidum***
3. Thallus crustose; ascigerous area well organized 4
4. Ascospores transversely septate 5
4. Ascospores muriform 14
5. Thallus foliicolous 6
5. Thallus corticolous 8
6. Ascomata black, very small (0.1–0.2 mm diam.), epruinose; ascospores microcephalic, often with one median cell slightly larger, 3-septate (14–16 × 4–5 µm) ..... ***Arthonia microcephala***
6. Ascomata variously coloured, medium-sized to large (0.3–1.0 mm diam.); ascospores macrocephalic, with the distal cell distinctly enlarged, 2–3(–5)-septate 7

7. Ascomata light to dark brown, epruinose, sharply delimited;
ascospores hyaline, 2-septate, 10–16 × 4–5 µm ..... ***Arthonia accolens***

7. Ascomata greenish brown to bluish grey, with a white pruina giving
a bluish appearance; ascospores hyaline to rarely slightly greyish brown,
regularly 2–5-septate, (6–)9–25 × 2–8 µm ..... ***Arthonia cyanea***

8. Ascomata pigmented, ± pruinose, epihymenium K+ purple 9

8. Ascomata unpigmented, epruinose, epihymenium K+ greenish or K– 10

9. Ascomata mostly round to irregular, brown, white pruinose;
margins with cinnabar-red pruina, 0.5–1 × 0.2–0.8 mm;
ascospores hyaline to brown at maturity, transversely 3–5-septate,
15–20 × 7–9 µm ..... ***Arthonia cinnabarina***

9. Ascomata shortly elongate, irregularly to stellately branched, black, epruinose
to reddish brown pruinose near the margins, 1–2 × 0.1–0.2 mm;
ascospores hyaline, transversely 5-septate, 10–12 × 3–5 µm ... ***Arthonia elegans***

10. Ascomata pale brown to reddish brown 11

10. Ascomata black 12

11. Ascomata pale brown, round to irregular, 1–2× 0.5–1 mm;
ascospores hyaline transversely 1–3-septate,
11–17 × 4–7 µm ..... ***Arthonia antillarum***

11. Ascomata reddish brown, shortly elongate, linear, bi- or trifurcate;
ascospores hyaline, transversely 4-septate,
30–35 × 10–12 µm ..... ***Arthonia pyrrhuliza***

12. Ascomata round to irregular; ascospores hyaline to grey-brown at maturity,
transversely 3–4-septate, with large, undivided upper and lower cells,
20–28 × 7–11 µm ..... ***Arthonia complanata***

12. Ascomata substellate or slightly elongate 13

13. Ascomata substellate to irregular, 1–1.5 mm in diam.;
ascospores hyaline to grey brown, transversely 3-septate,
14–16 × 4–5 µm ..... ***Arthonia radiata***

13. Ascomata slightly elongate, often curved or flexuose, occasionally
branched with a slightly raised margin, 1–1.5 × 0.1–0.5 mm;
ascospores hyaline, 1-septate, 20–25 × 8–10 µm ..... ***Arthonia excipienda***

14. Thallus thin, algal layer indistinct; ascomata reddish black, 1–2 mm in diam.;
ascospores hyaline, 20–25 × 7–10 µm ..... ***Arthothelium ruanum***

14. Thallus thick, algal layer ± distinct; ascomata black,
flaking away from the thallus at maturity, 0.5–1 × 0.3–0.5 mm;
ascospores hyaline, soon brownish, 35–40 × 10–15 µm ***Arthothelium spectabile***

15. Thallus pale mineral-grey to green or whitish green,
hypothallus brown; prothallus made up of radiating whitish hyphae;
pseudoisidia disc-shaped (schizidia), pale to off-white,
flattened to slightly convex with round to wavy margin, ≤1 mm diam.;
protocetraric and hypoprotocetraric acids present ..... ***Herpothallon sipmanii***

15. Thallus colour various; pseudoisidia loose or compact, cylindrical to irregular; chemistry lacking protocetraric and hypoprotocetraric acids 16

16. Pigments absent; 2′-O-methylperlatolic acid present ..... ***Herpothallon minimum***

16. Pigments (K+ purple) present; lacking 2′-O-methylperlatolic acid 17

17. Thallus greenish grey to greyish orange, rather loose; hypothallus byssoid, brownish to greenish black; prothallus whitish to pale greenish orange; pseudoisidia cylindrical rarely globose, byssoid, concolorous with thallus or strongly pigmented, ≤0.6 mm long and wide; norstictic acid present ..... ***Crypthonia mycelioides***

17. Thallus greenish grey to reddish green; hypothallus and prothallus byssoid, deep red; pseudoisidia rather compact and robust, entirely red, 0.5 × 0.4 mm; chiodectonic acid present ..... ***Herpothallon rubrocinctum***

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Three new species of lichenized fungi from Qinghai Province, China

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Abstract—Three new species of lichenized fungi—*Calogaya qinghaiensis, Caloplaca zeorina,Verrucaria eminens*—are described from Qinghai province, China, and compared with closely related species.

Key words—biodiversity, *Teloschistaceae*, *Verrucariaceae*, taxonomy

Introduction

Qinghai province is located at 31–39°N 89–103°E on the northeast Tibetan Plateau. The province consists of mountains and high plateaus with an average 3000 m elevation (the lowest basin approximately 2700 m a.s.l.) and featuring numerous lakes, including Qinghai Lake, the second largest saltwater lake in the world (Encyclopedia Britannica 2015, China.org.cn 2015). Such a variable environment, encompassing both xerophytic and halophytic conditions, supports a rich lichen diversity that remains less well explored than in the surrounding provinces of Gansu, Sichuan, Xizang, and Xinjiang.

The earliest explorations and surveys of the lichenological flora of Qinghai were conducted by G.N. Potanin in 1876–94 and B. Bohlin in 1930–32 (Wei 1991), and new species and records continue to be reported from this region in the 21st century (Fu & al. 2009; Hou & al. 2014; Liu & al. 2016; Wang & al. 2012, 2015).

During a 2014 summer field excursion to Qinghai Province organized by Dr. H.-Y. Wang of Shandong Normal University, three specimens were collected that were identified to genus but did not correspond with any of the described species. We propose them here as new species: *Calogaya qinghaiensis*, *Caloplaca zeorina*, and *Verrucaria eminens*. All specimens collected on the 2014 excursion were first deposited in the herbarium of the Korean Lichen Research Institute, Suncheon, Korea (KoLRI) and then transferred to the herbarium of the Korea National Arboretum (KH), Korea, in 2016.

Materials & methods

The specimens were examined morphologically under a Nikon SMZ645 stereo-zoom dissecting microscope, and thin hand-cut sections were made with a razor blade for observation of anatomical features under a Nikon Eclipse E200 compound microscope. Anatomical mages were captured with the AxioVison Release 4.8.2 software program and Axiocam ERc 5s camera mounted on a Zeiss A1 microscope. Length and diameter of at least ten ascospores per specimen were measured in water at 400× magnification. Thin-layer chromatography (TLC) was performed in Solvent systems A and C as per Orange & al. (2001), and HPLC was conducted as per Søchting (1997).

DNA was extracted from all specimens representing new and closely related species employing the DNA extraction kit NucleoSpin® Plant II. The full internal transcribed spacer (ITS) region (ITS1+5.8S +ITS2 rDNA) was amplified using Bioneer's AccuPower PCR Premix in 20 µl tubes employing primers ITS1F (Gardes & Bruns 1993) and ITS4 (White & al. 1990). PCR thermal cycling parameters followed Ekman (2001). Additionally, DNA was cloned using the pGEM®-T Easy Vector Systems when PCR and electrophoresis results were unclear or double bands were observed. The PCR products were sequenced by GenoTech (Daejeon, Korea), and the sequences were aligned and manually edited using ClustalW in Bioedit (V7.2.5).

For phylogenetic analysis, all DNA sequences were arranged and edited in MEGA6. Bootstrap values were obtained in ClustalX 2.1 (Larkin & al. 2007) and RAxML GUI 1.5 beta (Silvestro & Michalak 2010) using Maximum Likelihood (ML) with a rapid bootstrap, 1000 bootstrap replications, and GTR GAMMA for the substitution matrix. Posterior probabilities were produced in BEAUti 1.8.0 and BEAST 1.8.0 (Drummond & al. 2012) employing the HKY method for the substitution model, empirical base frequency, gamma for site heterogeneity model and four categories

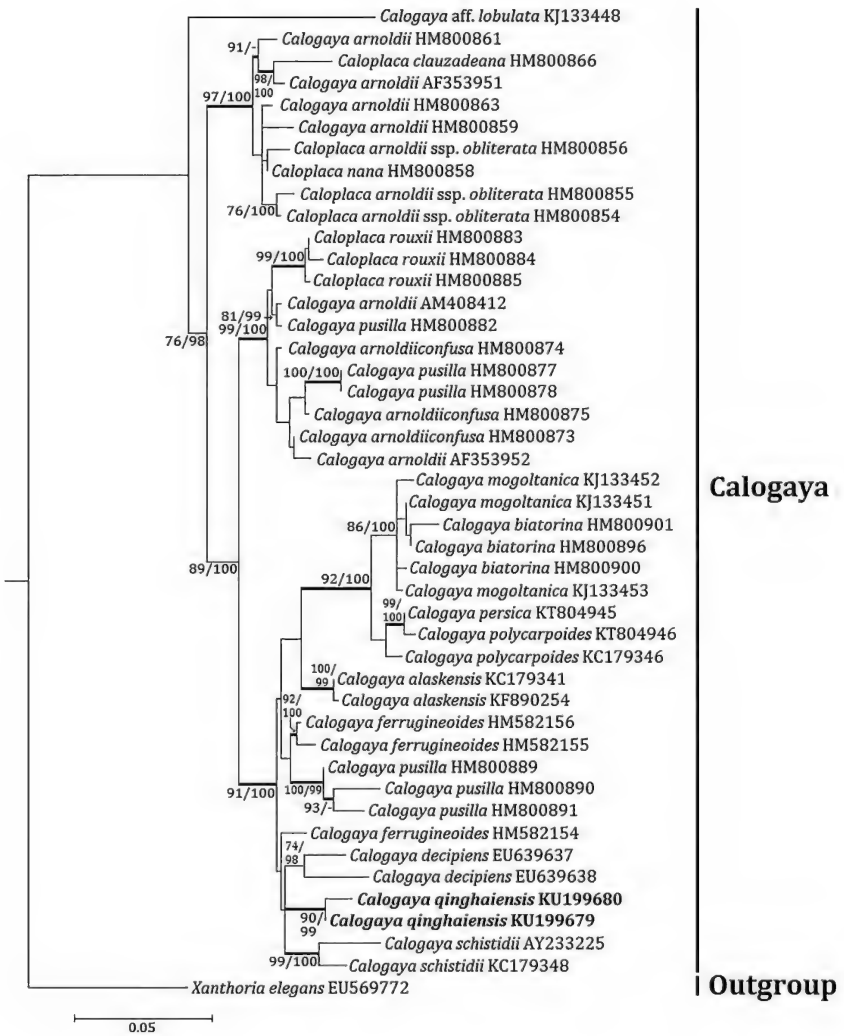

Plate 1. Phylogenetic relationships in *Calogaya*, based on a Maximum Likelihood analysis of the nuclear ribosomal ITS1-5.8S-ITS2 region. The tree was rooted using *Xanthoria elegans*. Maximum Likelihood bootstrap values ≥70% and posterior probabilities ≥95% are shown above internal branches. Branches with bootstrap values ≥90% are in bold. New sequences are presented in bold and all species names are followed by GenBank accession numbers. A dash indicates branches with posterior probabilities <95%.

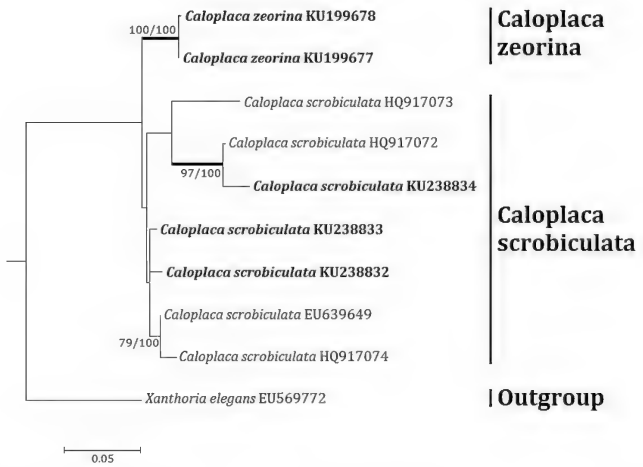

Plate 2. Phylogenetic relationships among compatible species surrounding *Caloplaca scrobiculata*, based on a Maximum Likelihood analysis of the nuclear ribosomal ITS1-5.8S-ITS2 region. The tree was rooted using *Xanthoria elegans*. Maximum Likelihood bootstrap values ≥70% and posterior probabilities ≥95% are shown above internal branches. Branches with bootstrap values ≥90% are in bold. New sequences are presented in bold and all species names are followed by GenBank accession numbers. A dash indicates branches with posterior probabilities <95%.

for gamma, and one million MCMC (Markov Chain Monte Carlo) chain length with ten thousand echo state screening and two hundred log parameters. The best tree was determined using TreeAnnotator 1.8.0 (Drummond & Rambaut 2007) with a burn-in of one hundred, no posterior probability limit, a maximum clade credibility tree for target tree type, and median node heights. All trees were illustrated in FigTree 1.4.2 (Rambaut 2014) and edited in Microsoft Paint.

Results & discussion

The *Calogaya* phylogenetic tree (Pl. 1) was produced from 43 GenBank sequences (34 for *Calogaya*, eight for *Caloplaca*, one for an outgroup *Xanthoria elegans*) and two new sequences from our new species, *C. qinghaiensis*. *Calogaya qinghaiensis* is positioned within *Calogaya* (previously *Caloplaca saxicola* group), which comprises *C. alaskensis* (Wetmore) Arup & al., *C. arnoldii* (Wedd.) Arup & al. (including several subspecies), *C. arnoldiiconfusa* (Gaya & Nav.-Ros.) Arup & al., *C. biatorina* (A. Massal.) Arup & al., *C. decipiens* (Arnold) Arup & al., *C. ferrugineoides* (H. Magn.) Arup & al., *C. lobulata* (Flörke) Arup & al., *C. mogoltanica* (S.Y. Kondr. & Kudratov) S.Y. Kondr. & al., *C. persica* (J. Steiner) Arup & al., *C. polycarpoides* (J. Steiner) Arup & al., *C. pusilla* (A. Massal.) Arup

& al., *C. schistidii* (Anzi) Arup & al., and *Caloplaca rouxii* Gaya & al. *Calogaya qinghaiensis* forms a well supported monophyletic clade, but our analysis did not reveal any clear relationship with adjacent clades.

The phylogenetic tree for the *Caloplaca scrobiculata* group (Pl. 2) was produced from five GenBank sequences (four for *Caloplaca* spp., one for an outgroup *X. elegans*) and five new sequences (two for *C. zeorina,* three for *C. scrobiculata*). Our analysis supports *Caloplaca zeorina* as a sister clade to *C. scrobiculata*.

A phylogenetic tree for *Verrucaria* (not shown), including our new sequences from *V. eminens* and *V. pinguicula*, placed *V. eminens* as basal to all other sequenced *Verrucaria* species but with very low support.

Taxonomy

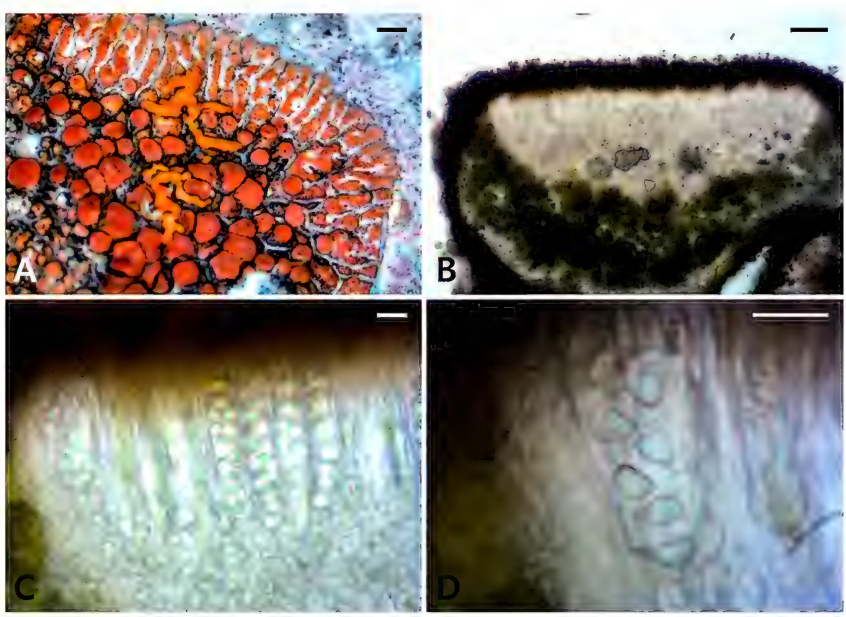

Plate 3. *Calogaya qinghaiensis* (holotype, KoLRI 024154). A. habitus; B. section through apothecium; C, D. asci and ascospores. Scale bars: A = 1 mm; B = 50 µm; C, D = 10 µm.

Calogaya qinghaiensis B.G. Lee & Hur, **sp. nov.** Pl. 3

MycoBank MB 815074

Differs from *C. decipiens* by an absence of soralia/soredia, its frequent apothecia, and its reddish apothecial discs.

Type: China, Qinghai province, Tianjun County, Yangkang village, 37°43′15″N 98°32′09″E, 3688 m, 28 July 2014, S.O. Oh, S.K. Han, & J.S. Hur CH140258 (**Holotype**, KoLRI 024154; GenBank KU199679).

Etymology: The species epithet indicates the collection locality, Qinghai.

Morphology—Thallus crustose, reddish-orange, 1.7–2.4 cm diam., pruinose, placodioid, margin abrupt at edge. Lobes convex, marginally narrow, 1.7–2.5 × 0.4–0.8 mm, surface white pruinose. Cortex cellular, 25–32.5 µm thick, with granules insoluble in K. Medulla prosoplectenchymatous, 90–100 µm high, with granules insoluble in K. Apothecia adnate, 0.3–0.9 mm diam., lecanorine. Disc reddish-orange, flat, mainly epruinose or slightly white pruinose. Thalline margin persistent, slightly raised above disc level. Proper margin thin, concolorous with disc. Epihymenium brown to light brown, 30.0–33.8 µm tall, K+ purple. Hymenium hyaline, 49.1–75.0 µm tall. Subhymenium hyaline, 28.8–47.1 µm tall. Hypothecium hyaline, 44.3–54.3 µm tall. Paraphyses simple, unbranched, with 1–2 swollen tip cells. Asci cylindrical, 8-spored. Ascospores hyaline, ellipsoid, 10–12.5 × 5–6.25 µm, septum 1.5–3 µm high, spore end wall thin. Pycnidia not observed.

Chemistry—Thallus and apothecial disc K+ purple, C–, KC–, P–. UV+ red to dark orange. Parietin detected by TLC and HPLC.

Ecology & distribution—So far known only from its type locality where it grows on rocks associated with *Caloplaca scrobiculata, Oxnerella safavidiorum* S.Y. Kondr. & al., and *Xanthoria elegans* (Link) Th. Fr.

Additional specimen examined: **China, Qinghai province, Tianjun County,** Yangkang village, 37°43′15″N 98°32′09″E, 3688 m, 28 July 2014, S.O. Oh, S.K. Han, & J.S. Hur CH140262 (KoLRI 024158; GenBank KU199680).

Remarks—*Calogaya qinghaiensis* shares morphological similarities with *C. arnoldii*, *C. biatorina*, *C. decipiens*, *C. ferrugineoides*, *C. pusilla,* and *C. schistidii*.

Calogaya arnoldii differs from *C. qinghaiensis* by its smaller thallus, irregularly arranged marginal lobes, no differentiation of both proper and thalline margins, thinner epihymenium, and wider ascospore septa (Gaya 2009); *C. biatorina* is distinguished by its epruinose thallus, mostly flat lobes, and larger ascospores (Gaya 2009); and *C. decipiens* differs in its dark orange apothecia, presence of soralia/soredia, larger ascospores, and the presence of emodin (Gaya 2009).

Calogaya ferrugineoides differs from *C. qinghaiensis* by its colonization of bark, cork, trunks, branches, or twigs, its grayish colored thallus with inconspicuous thallus margin, and the absence of parietin (LIAS light 2018);

C. pusilla is distinguished by unbranched paraphysis tips, slightly larger ascospores, wider septa, and the presence of fallacinal, emodin, teloschistin and parietin (Nash III & al. 2007); and *C. schistidii* differs in its bryophytic substrates (mosses and liverworts), inconspicuous thallus margin, epruinose thallus, yellow epihymenium, and larger ascospores (Gaya 2009).

Caloplaca zeorina B.G. Lee & Hur, **sp. nov.** Pl. 4

MycoBank MB 815073

Differs from *C. anularis* by the presence of zeorin, its completely divided biloculate spores, and living central areoles.

Type: China, Qinghai prov., Haidong prefecture, Mt. Dabanshan, 37°21′04″N 101°24′25″E, 3792 m, 25 July 2014, S.O. Oh, S.K. Han, & J.S. Hur CH140080 (**Holotype**, KoLRI 023976; GenBank KU199677, KU199678).

Etymology: The species epithet indicates the chemical characteristic of zeorin containment.

Morphology—Thallus crustose, reddish-orange, 0.5–0.75 cm diam., up to 480 µm thick, placodioid, margin abrupt at edge. Lobes convex, marginally narrow, 0.7–2.2 × 0.2–0.8(–1.1) mm, surface smooth, white epruinose. Cortex amorphous, 62.5–100 µm thick, with granules insoluble in K. Medulla prosoplectenchymatous, dense, 70–100 µm high, with granules insoluble in K. Apothecia adnate, 0.4–1.1 mm diam., lecanorine. Disc red to orange. Proper margin visible, darker than the disc. Epihymenium brown to light orangish brown, 20.5–38.6 µm tall, K+ purple. Hymenium hyaline, 53.0–76.6 µm tall. Subhymenium hyaline, 60.0–74.6 µm tall. Hypothecium hyaline, 56–100 µm tall. Paraphyses simple, unbranched, with 1–2 swollen tip cells. Asci cylindrical, 8-spored. Ascospores hyaline, ellipsoid, 14–16 × 5.5–10 µm, completely separated into two locules by a narrow septum, ≤1 µm long. Pycnidia not observed.

Chemistry—Thallus and epihymenium K+ red-purple, C–, KC–, P– by spot test, UV+ red to dark orange; parietin, teloschistin, and zeorin detected by TLC; parietin detected by HPLC (teloshistin and zeorin not in the HPLC library).

Ecology & distribution—*Caloplaca zeorina* occurs on rock and is currently known only from the type collection (Qinghai province, China).

Additional specimens examined: ***Caloplaca scrobiculata***: **China, Qinghai province, Tianjun County,** Yangkang village, 37°43′15″N 98°32′09″E, 3688 m, 28 July 2014, S.O. Oh, S.K. Han, & J.S. Hur CH140280 (KoLRI 024176; GenBank KU238832), CH140273 (KoLRI 024169; GenBank KU238833), CH140283 (KoLRI 024179; GenBank KU238834).

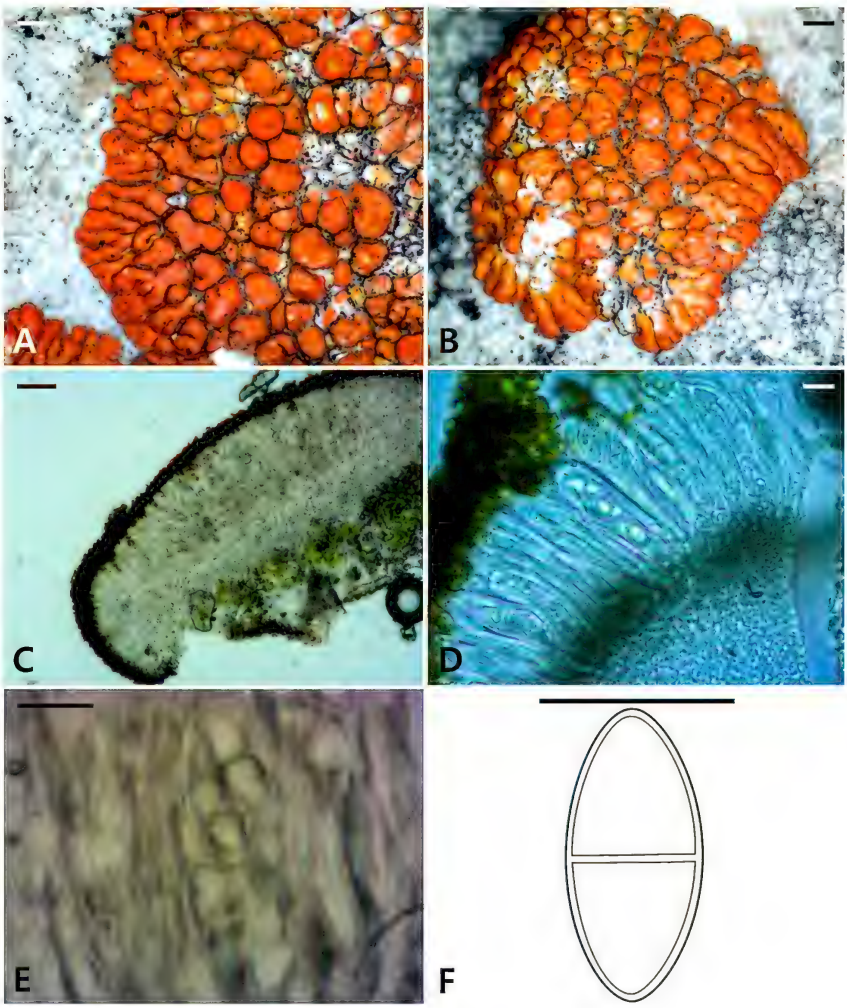

PLATE 4. *Caloplaca zeorina* (holotype, KoLRI 023976). A, B. habitus; C, D. section through apothecium; E. asci and ascospores; F. ascospore. Scale bars: A, B = 1 mm; C = 50 μm; D–F = 10 μm.

REMARKS—*Caloplaca zeorina* contains the triterpenoid zeorin, the presence of which separates it from other *Caloplaca* species, which typically contain anthraquinones such as parietin, fallacinal, emodin, and/or teloschistin.

Caloplaca zeorina shares several similarities with *C. scrobiculata* and *C. anularis* Clauzade & Poelt. The synonymy of *Caloplca anularis* with

C. scrobiculata by Poelt & Hinteregger (1993) was accepted by a number of authors and cited in the checklists for Austria (Hafellner & Türk 2001), Bulgaria (Mayrhofer & al. 2005), France (Roux 2012), Italy (Nimis & Martellos 2008), Montenegro (Knežević & Mayrhofer 2009), Slovakia (Pišút & al. 1996), and Slovenia (Suppan & al. 2000). However, Khodosovtsev & al. (2004) and Vondrák & Mayrhofer (2013) argued convincingly that these two *Caloplaca* species are quite different from each other and should be treated separately.

Caloplaca zeorina shares more similarities with *C. anularis* than with *C. scrobiculata*: *C. anularis* differs in its yellow to slightly orange-yellow colored and thicker thallus, thicker medulla, narrower ascospores with an undivided single locule and constricted in the middle, and its central areoles that die and fall off, leaving only the margins and displaying ring-shaped thallus fragments (Vondrák & Mayrhofer 2013).

Although possessing ascospores that are quite similar to those found in *C. zeorina*, *C. scrobiculata* is distinguished by its yellow to orange-yellow colored pruinose thallus, absence of a cortical layer and a marginal lobe, longer and narrower ascospores, and the absence of zeorin (Vondrák & Mayrhofer 2013).

Caloplaca zeorina can be confused with *C. ignea* Arup (≡ *Polycauliona ignea* (Arup) Arup & al.) and *C. rouxii,* which also inhabit a rock substratum and produce a thallus that is thick with convex marginal lobes, smooth, reddish, epruinose, and gives a K+ purple reaction. *Caloplaca ignea* is distinguished by its flatter, longer lobes, much thinner cortex, smaller ascospores with a wider septum, the presence of pycnidia, and the absence of zeorin (Nash III & al. 2007). *Caloplaca rouxii* differs in producing a thallus loosely attached to the substratum, shorter and narrower lobes, discolored patches on upper surface, a thinner thallus, cortex, medulla, and algal layer, an apothecial margin color lighter than the disc, a much thinner epihymenium, narrower ascospores with a wider septum, and the absence of zeorin (Gaya 2009).

Verrucaria eminens B.G. Lee & Hur, **sp. nov.** Pl. 5

MycoBank MB 815075

Differs from *V. pinguicula* by a rimose thallus with blackish brown or green pigments, distinctive ostiolar region, and small, round ascospores.

Type: China, Qinghai province, Haidong prefecture, Mt. Dabanshan, 37°20′17″N 101°23′53″E, 3745 m, 25 July 2014, S.O. Oh, S.K. Han, & J.S. Hur, CH140035 (**Holotype**, KoLRI 023931; Genbank KU199681).

Etymology: The species epithet refers to the prominent, large perithecia.

Morphology—Thallus, 272–352 µm thick, rimose, wrinkled, with numerous cracks, dull-white colored, cracks with blackish brown or green pigments (perhaps an algal layer shown inside the cracks), epinecral layer present, pale brown, 7.9–8.7 µm tall. Cortex hyaline or slightly darkened, 11–13.6 µm tall. Algal layer continuous to irregularly discontinuous or isolated in medulla, 80.4–86.6 µm tall. Photobiont cells 7.5 × 5 µm thick. Medulla 38.9–47.6 µm tall. Perithecia prominent (118.3–182.5 µm), sometimes immersed (97.9–113.8 µm), (243–)318(–419) µm diam., often in groups of 2–3, rarely solitary, concave with rounded apex, black. Ostiolar region whitish to pale brown, protruding as a low papilla, c. 200 µm diam. Involucrellum well developed, partly lateral, black, reaching up to the base of the exciple. Periphyses irregularly septate, diameters approximately 29 µm at the base and 42.5–55 µm at the ostiolar region. Asci 30–45 × 17.5–20 µm, 8-spored. Ascospores ellipsoidal to globose, 10.4–15.0 × 8.0–11.1 µm (mean = 12.3 × 9.6; n = 26).

Chemistry—K–, C–, KC–, P–. UV–. No substances detected by TLC.

Ecology & distribution—The species occurs with *Caloplaca* species on calcareous rocks in sunny areas. This species is currently known only from the type collection.

Additional specimen examined: ***Verrucaria pinguicula*** A. Massal.: **South Korea, Gangwon province, Jeongseon-gun,** Jeongseon-eup, Aesan-ri, 37°22′17″N 128°40′25″E, 320 m, 06 Sep 2015, B.G. Lee, J.J. Woo, & J.S. Park 152773 (KoLRI 037760; Genbank KU215797).

Remarks—*Verrucaria eminens* is not easily confused with *V. caerulea* DC., *V. canella* Nyl., *V. dufourii* DC., *V. muralis* Ach., and *V. pinguicula* despite sharing common features such as their substrate preference for calcareous rocks, ±superficial visibly cracked, indistinct prothallus and ±prominent perithecia. However, *V. caerulea* is separated by its non-rimose, pale gray to dull gray-brown, and thinner thallus, less prominent, smaller perithecia, and larger and ellipsoid ascospores (Smith & al. 2009); *V. canella* differs in its thicker pruinose thallus with discrete areoles, three-quarters to completely immersed perithecia, absence of an involucrellum, larger and oblong to ellipsoid ascospores, and the presence of a perispore (Smith & al. 2009); *V. dufourii* is distinguished by its immersed thallus, an inconspicuous ostiolar region, an involucrellum that does not reach the exciple base, larger and oblong to ellipsoid ascospores, and the presence of pycnidia (Smith & al. 2009); and *V. muralis* differs in its thallus usually without pigments, an involucrellum that does not usually reach the exciple base, and larger and oblong to ellipsoid ascospores (Smith & al. 2009).

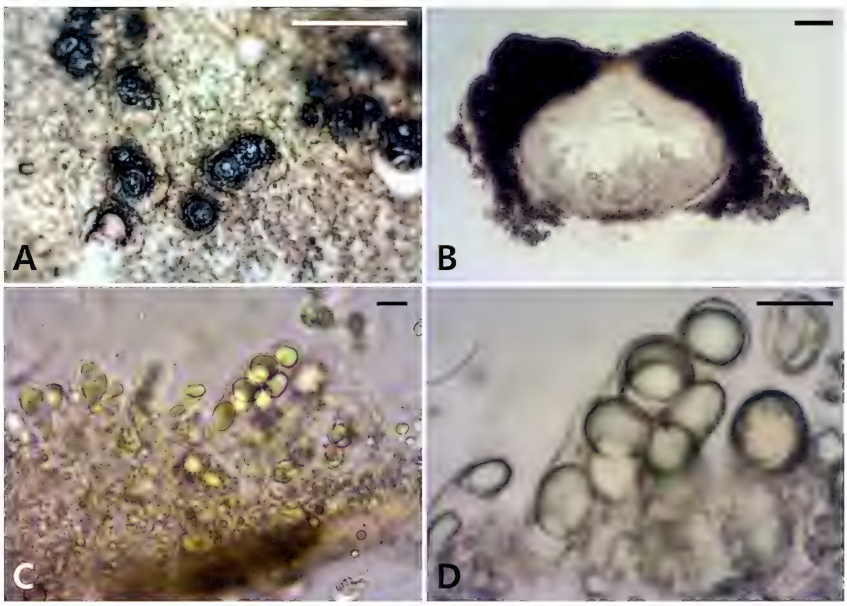

Plate 5. *Verrucaria eminens* (holotype, KoLRI 023931). A. habitus; B. section through perithecium; C. ascoma position; D. ascospores in an ascus. Scale bars: A = 1 mm; B = 50 µm; C, D = 10 µm.

Verrucaria pinguicula, which also produces prominent large perithecia, differs in its superficial or almost immersed thallus, inconspicuous ostioles, and larger (13.5–18 × 5.5–8.5 µm) oblong-ellipsoid spores (Smith & al. 2009).

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New records of pyrenocarpous lichens from Jeju Island, South Korea

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Abstract—Based on the morphological study of specimens collected from Jeju Island, ten pyrenocarpous lichen-forming fungi are reported for the first time from South Korea: *Agonimia globulifera, A. repleta, Anisomeridium japonicum, A. robustum, Anthracothecium macrosporum, Psoroglaena japonica, Strigula aquatica, Thelidium japonicum, T. pluvium,* and *T. radiatum.* Technical morphological descriptions and photographs of the Korean specimens are presented with the ecology and distribution for each species.

Key words—*Monoblastiaceae, Pyrenulaceae, Strigulaceae,* taxonomy, *Verrucariaceae*

Introduction

Pyrenocarpous lichens comprise a large number of species in tropical and subtropical areas, especially in freshwater and shaded habitats; despite their common and wide distribution, very little attention has been given to them. Several recent regional surveys have been conducted in Costa Rica (Aptroot & al. 2008), Europe (Coppins & Aptroot 2008, Orange 2008), Australia (McCarthy 2001), Japan (Harada 2001), and Korea (Moon & Aptroot

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2009), where many pyrenocarpous lichens species were recorded living on corticolous, foliicolous, and saxicolous substrates.

Although exploration of Korean lichen mycota has made considerable progress in recent years (Aptroot & Moon 2014; Hur & al. 2005; Kondratyuk & al. 2013, 2015, 2016a, b, 2017; Moon 2013), knowledge of the flora of pyrenocarpous lichen in these areas is far from complete. Our current research continues our investigation of Korean lichen mycota, chiefly in Jeju Island (southern coast of Korea); here we add information on ten pyrenocarpous lichens, all of which represent new records for South Korea.

Materials & methods

Specimens were collected from Jeju Island during 2014–15 and deposited in the herbarium of the Korean Lichen Research Institute, Suncheon, South Korea (KoLRI), now incorporated into the lichen herbarium of Korean National Arboretum, Pocheon, South Korea (KH). The morphology was examined with the aid of an Olympus SZX-7 stereomicroscope and an Olympus BX-50 compound microscope with DIC optics and photographed with a Canon 5D digital camera. Hand-sections were made by razor blade under a dissecting stereoscope, and mounted in water. All measurements were made in water, while 10% KOH was used for observing asci and ascospores in more detail.

Taxonomy

Agonimia globulifera M. Brand & Diederich, Lejeunia 162: 8 (1999)

Thallus green to dark greenish, small to medium size. Lobes irregular or cylindrical, 20–50 µm wide, aggregated into larger (0.02–0.05 mm), lobed squamules. Photobiont green alga. Sterile globules usually frequent, subspherical, black, shiny, superficial to ⅓ immersed, 70–200 µm diam., composed of pseudoparenchymatous cells; cells thin-walled, with an oil drop. Prothallus not distinct. Perithecia and pycnidia not seen in Korean specimen.

Ecology & distribution—The Korean specimen was found growing over moss on shaded basalt boulders near a stream accompanied by *Fuscopannaria dissecta* and *Nephroma resupinatum*. *Agonimia globulifera* has been recorded from Europe, northern Asia, North America, and the subantarctic archipelago (Hafellner 2014, Sérusiaux & al. 1999); new to South Korea.

Specimen examined—**SOUTH KOREA. Jeju-do, Seogwipo-si,** Halla Mountains, Eorimok Trail, 33°23′05″N 126°30′00″E, 1067 m asl, on moss over rock, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151692 (KoLRI 035385).

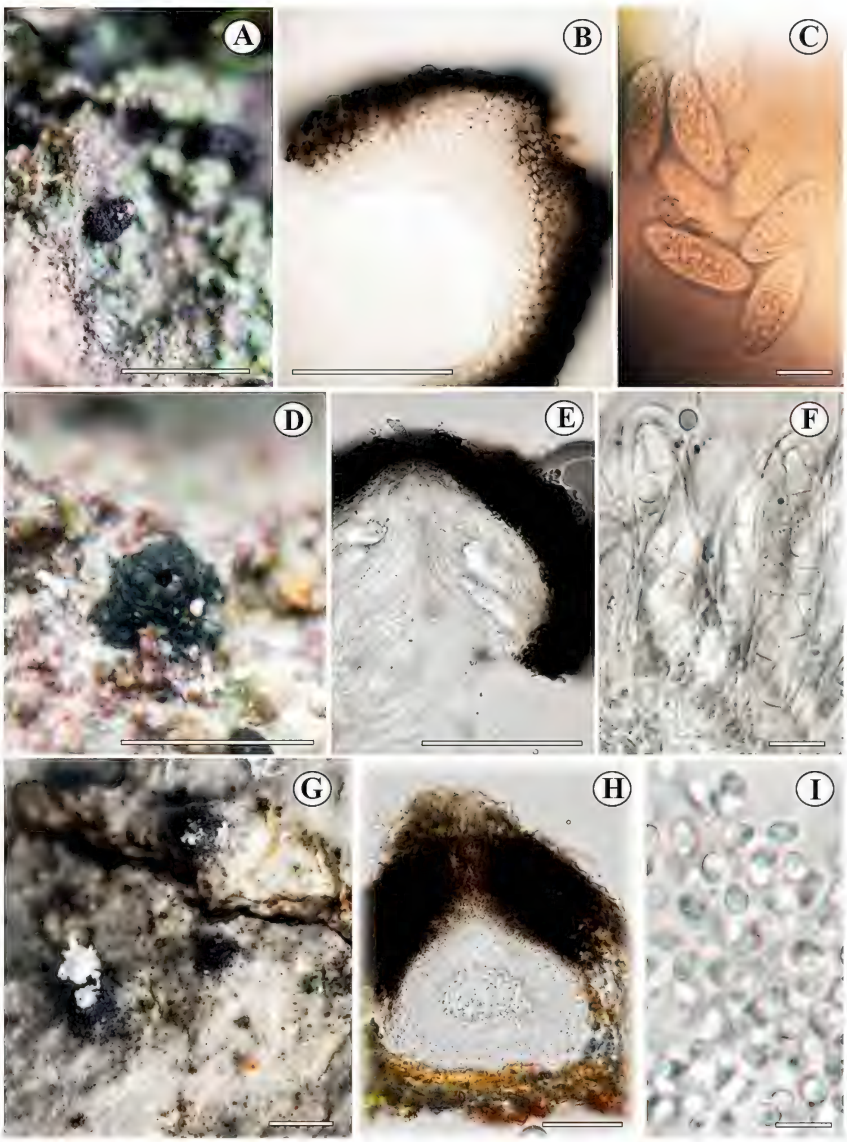

Plate 1. Pyrenocarpous lichens from South Korea: ***Agonimia repleta*** (KoLRI 035254), A. thallus with ascomata; B. ascoma, vertical section; C. ascospores. ***Anisomeridium japonicum*** (KoLRI 035220), D. thallus with ascomata; E. ascoma, vertical section; F. ascospores. ***Anisomeridium robustum*** (KoLRI 035252), G. thallus with pycnidia; H. pycnidium, vertical section; I. pycnospores. Scale bars: A, D, G = 500 μm; B, E, H = 100 μm; C = 20 μm; F, I = 10 μm.

Comments—The Korean specimen agrees with the description by Sérusiaux & al. (1999), but perithecia and pycnidia were not seen in the Korean material. *Agonimia globulifera* is similar to *A. koreana*, a species previously reported from South Korea distinguished by its larger squamules (0.2–0.4 mm; Kashiwadani 2008).

Agonimia repleta Czarnota & Coppins, Graphis Scripta, 11: 56 (2000) Pl. 1A–C

Thallus dull green, granular to verrucose or minutely squamulose; granules 30–120 µm diam.; squamules elongate if present, 240 × 100 µm. Photobiont green alga, 8–10 µm diam. Perithecia black, slightly immersed amongst thalline granules, 160–200 µm diam., globose when young but soon becoming pyriform, with a neck roughened by vertical channels. Ostiole brown to black. Asci clavate, 8-spored. Ascospores hyaline, globose or ellipsoid, muriform, 20–40 × 12–20 µm. Pycnidia not seen.

Ecology & distribution—The Korean specimen was found living on a mossy rock near a stream in deep shade accompanied by *Porpidia albocaerulescens* at the collection site. *Agonimia repleta* is known from Europe, northern Asia, North America, and the subantarctic archipelago (Hafellner 2014); new to South Korea.

Specimen examined—**SOUTH KOREA. Jeju-do, Jeju-si,** Halla Mts, Arail-dong, trail to Gwaneum Temple, 33°25′12″N 126°32′56″E, 601 m asl, on rock, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151561 (KoLRI 035254).

Comments—The Korean specimen agrees with the description of *Agonimia repleta* by Czarnota & Coppins (2000). The species resembles *A. tristicula* in producing pyriform perithecia with a longitudinally furrowed (plicate) necks, but *A. tristicula* is distinguished by 2-spored asci and much larger ascospores (57–120 × 26–50 µm; Orange 2008). *Agonimia repleta* also resembles *A. allobata* and *A. octospora*, both of which differ by their pale or pinkish ostiolar area (Orange 2008).

Anisomeridium japonicum H. Harada, Nat. Hist. Res. 5(2): 53 (1999) Pl. 1D–F

Saxicolous. Thallus crustose, continuous, greenish gray, thin, smooth. Hypothallus and margin not distinct. Photobiont *Trentepohlia*. Perithecia hemispherical, dark brown or almost black, rather abruptly delimited at base, with rounded apices, 150–200 µm diam.; ostioles apical, inconspicuous. Involucrellum extending to the exciple base, ca. 25 µm thick in the upper part, dark purplish brown. Exciple colourless, 10–15 µm thick. Pseudoparaphyses branched and anastomosing to form a network. Asci clavate, 40 × 10 µm. Ascospores hyaline, ellipsoidal to oval, 1-septate, with rounded apices, lacking epispore, 9–16 × 4–6 µm. Pycnidia not seen.

Ecology & distribution—The Korean specimens were found on mossy rocks near a stream under very shaded conditions accompanied by *Pilophorus clavatus* and *Thelidium japonicum* in the Halla Mountains. Our collections extend the range of *Anisomeridium japonicum* from Japan (Harada 1999) to South Korea.

Specimens examined—**SOUTH KOREA. Jeju-do, Jeju-si,** Halla Mts, Arail-dong, trail to Gwaneum Temple, 33°24′03″N 126°32′25″E, 868 m asl, on rock, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151525 (KoLRI 035218), 151526 (KoLRI 035219), 151527 (KoLRI 035220).

Comments—The Korean specimens found growing on non-calcareous rocks in a semi-freshwater habitat agree with the type description in Harada (1999). *Anisomeridium japonicum* is similar to *A. carinthiacum* and *A. distans,* but the ascospores are larger (13–18 × 5.5–7 µm) in *A. carinthiacum* has larger ascospores and 3-septate in *A. distans* (Harris 1995).

Anisomeridium robustum Orange, Coppins & Aptroot, Lichenologist 40: 363 (2008) Pl. 1G–I

Corticolous. Thallus thin, white or pale greyish, often cracked. Photobiont *Trentepohlia*. Pycnidia black, 180–320 µm diam., 150–250 µm high, with a globose or conical base tapering into a narrow, <1.5 mm long neck. Conidia hyaline, simple, pyriform to ellipsoid, with truncate base, 2.5–4 × 2–3 µm.

Ecology & distribution—The Korean specimens were found growing on the bark in more or less humid conditions associated with *Agonimia pacifica*. Our collections extend the range of *Anisomeridium robustum* from Europe (Coppins & Aptroot 2008) to South Korea.

Specimens examined—**SOUTH KOREA. Jeju-do: Jeju-si,** Halla Mts, Arail-dong, trail to Gwaneum Temple, 33°24′03″N 126°32′25″E, 868 m asl, on bark, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151559 (KoLRI 035252); **Seogwipo-si,** Halla Mts, Yeongsil Trail, 33°21′16″N 126°29′58″E, 1337 m asl, on bark, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151565 (KoLRI 035258).

Comments—The morphology of the Korean specimens agrees with the description of Coppins & Aptroot (2008) and represents a new record of *Anisomeridium robustum* not only for Korea, but also for Asia. The species is distinguished from the similar *A. polypori* by its much larger macropycnidia and conidia (Orange 2008).

Anthracothecium macrosporum (Hepp) Müll. Arg., Linnaea 43: 44 (1880) Pl. 2A–C

Corticolous. Thallus crustose, yellow to green, 10–30 cm diam., smooth, thick. Photobiont *Trentepohlia*. Perithecia prominent, hemispherical, usually

covered by thallus, yellowish brown to black, 1–1.5 mm diam. Ostiole brown. Involucrellum extending to the base, brownish black, 100–160 µm thick. Paraphyses simple to rarely branched or sparsely anastomosed, 1.5–2 µm diam. Asci clavate, bitunicate, 2-spored. Spores brown, oblong, with 10–15 transverse septa, 12–20-celled, 125–200 × 30–45 µm.

Ecology & distribution—The Korean material was found living on bark associated with *Anisomeridium robustum*, *Bacidina chloroticula*, and *Graphis anfractuosa*. *Anthracothecium macrosporum,* with pantropical distribution (Aptroot 2011), is new to South Korea.

Specimens examined—**SOUTH KOREA. Jeju-do, Jeju-si,** Halla Mts, Arail-dong, trail to Gwaneum Temple, 33°24′03″N 126°32′25″E, 868 m asl, on bark, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151544 (KoLRI 035237); 33°25′12″N 126°32′56″E, 601 m asl, on bark, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151579 (KoLRI 035272).

Comments—*Anthracothecium macrosporum* is characterized by a thick greenish thallus, large perithecia, thick involucrellum, apical ostiole, euseptate 2-spored asci, and large ascospores. *Anthracothecium prasinum* and *A. gregale* are close to *A. macrosporum* but can be distinguished by having 4–6-ascospores per ascus (Aptroot 2011).

Psoroglaena japonica H. Harada, Lichenology 2: 5 (2003) Pl. 2d–f

Saxicolous. Thallus crustose, farinose, spreading, green to dark green, 10 mm diam. Photobiont green alga. Perithecia immersed into rocks at base, hemispherical, ellipsoidal, or pyriform, pale orangish brown to dark brown, 0.2–0.4 mm diam. Exciple hyaline internal, orangish brown or brown in the outer layer. Periphyses hyaline, without prominently pointed or rounded apices, 20–25 µm long, 1–1.5 µm thick. Ascus clavate, 8-pored, 60–80 × 10 µm. Ascospores oval, hyaline, 13–17 × 5–6 µm, 3-septate. Pycnidia not seen.

Ecology & distribution—The Korean material was found growing on basalt rock accompanied by *Agonimia pacifica*, *Fuscopannaria dissecta*, *Graphis anfractuosa,* and *Pilophorus clavatus*. Our collection extends the range of *Psoroglaena japonica* from Japan (Harada 2003) to South Korea.

Specimen examined—**SOUTH KOREA. Jeju-do, Seogwipo-si,** Halla Mts, Yeongsil Trail, 33°21′12″N 126°29′52″E, 1308 m asl, on rock, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151671 (KoLRI 035364).

Comments—The Korean specimen matches the type description by Harada (2003). *Psoroglaena japonica* is most similar to *P. stigonemoides*, which differs by its filamentous to granular thallus with papillose cortical cells, its pale perithecia, its 3–5-septate ascospores, and its corticolous habit (Orange 1989). Epiphytic *P. cubensis* resembles *P. japonica* but differs in forming a

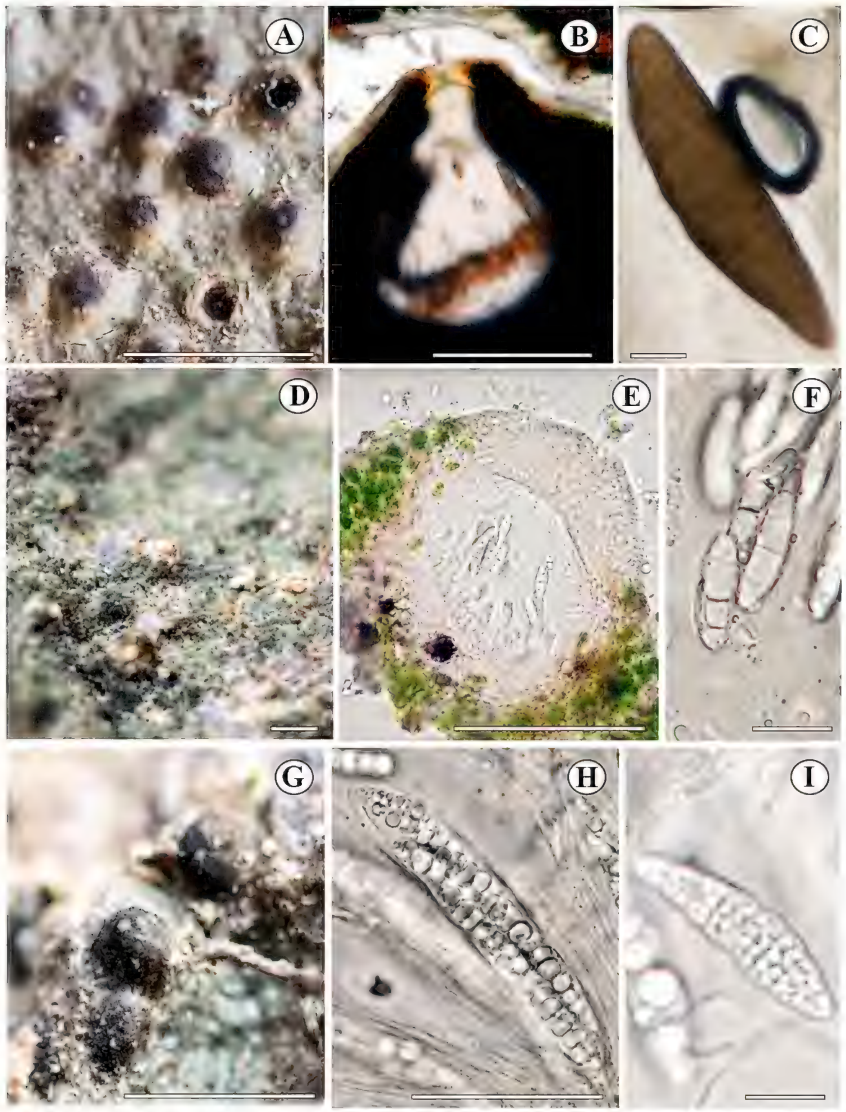

Plate 2. Pyrenocarpous lichens from South Korea: ***Anthracothecium macrosporum*** (KoLRI 035272), A. thallus with ascomata; B. ascoma, vertical section; C. ascospores. ***Psoroglaena japonica*** (KoLRI 035364), D. thallus with ascomata; E. ascoma, vertical section; F. ascospores. ***Strigula aquatica*** (KoLRI 035221), G. thallus with ascomata; H. ascus with ascospores; I. ascospore. Scale bars: A = 3 mm; B, D, E = 100 µm; C, F, I = 10 µm; G = 500 µm; H = 50 µm.

finely lobate thallus (Eriksson 1992). Two other close species, *P. perminuta* and *Phylloblastia borhidii*, are foliicolous species and known only from Africa (McCarthy & Kantvilas 2013).

Strigula aquatica H. Harada, Nova Hedwigia 66: 420 (1998) Pl. 2G–I

Saxicolous. Thallus continuous, thin, grey; hypothallus filmy, whitish. Perithecia, hemispherical, dark brown to black near the apex, papillate at the apical ostiole or round at the top, widely pyriform, 190–260 × 240–330 µm. Photobiont *Trentepohlia*. Involucrellum dark brown. Exciple brown in the upper part, hyaline in lower part. Periphyses indistinct, simple, hyaline. Paraphyses unbranched, septate, 1.5 µm thick. Asci cylindrical, 8-spored, 75 × 15 µm. Spores fusiform, hyaline, 7-septate, thin-walled, slightly constricted in the middle, 26–30 × 6–7 µm. Pycnidia not seen.

Ecology & distribution—The Korean material was found growing on basalt stones in the banks of a brook associated with *Agonimia pacifica* and *Pilophorus clavatus*. Our collections extend the range of *Strigula aquatica* from Japan (Harada 1998) to South Korea.

Specimens examined—**SOUTH KOREA. Jeju-do, Jeju-si,** Halla Mts, Arail-dong, trail to Gwaneum Temple, 33°24′03″N 126°32′25″E, 868 m asl, on rock, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151528 (KoLRI 035221), 151529 (KoLRI 035222), 151531 (KoLRI 035224).

Comments—*Strigula aquatica* is characterized by its continuous pale greenish-gray thallus, scattered dome shaped perithecia, non-carbonized involucrellum, and 7-septate fusiform hyaline ascospores. Contrasted with other similar saxicolous *Strigula* species, *S. nipponica* differs in having a carbonized involucrellum, while *S. confusa* and *S. rupestris* are distinguished by muriform ascospores (Harada 2016, McCarthy 1997, Orange 2008).

Thelidium japonicum H. Harada, Nat. His. Res. 1(2): 9 (1991) Pl. 3A–C

Saxicolous. Thallus distinct or inconspicuous, green or greenish brown, granulose to areolate. Phycobiont cells isodiametric. Hypothallus black, gelatinous, not distinct. Perithecia abundant, hemispherical, 100–200 µm diam., with a very dark brown to black wall; ostiolar part pale to dark brown. Involucrellum inconspicuous or absent. Exciple colorless. Asci clavate, 8-spored, 85 × 25 µm, bitunicate. Spores hyaline, thin-walled, 1-septate, 17–26 × 8–12 µm. Pycnidia not seen.

Ecology & distribution—The Korean specimens were found growing on basalt rocks together with *Agonimia pacifica*, *Anisomeridium japonicum*,

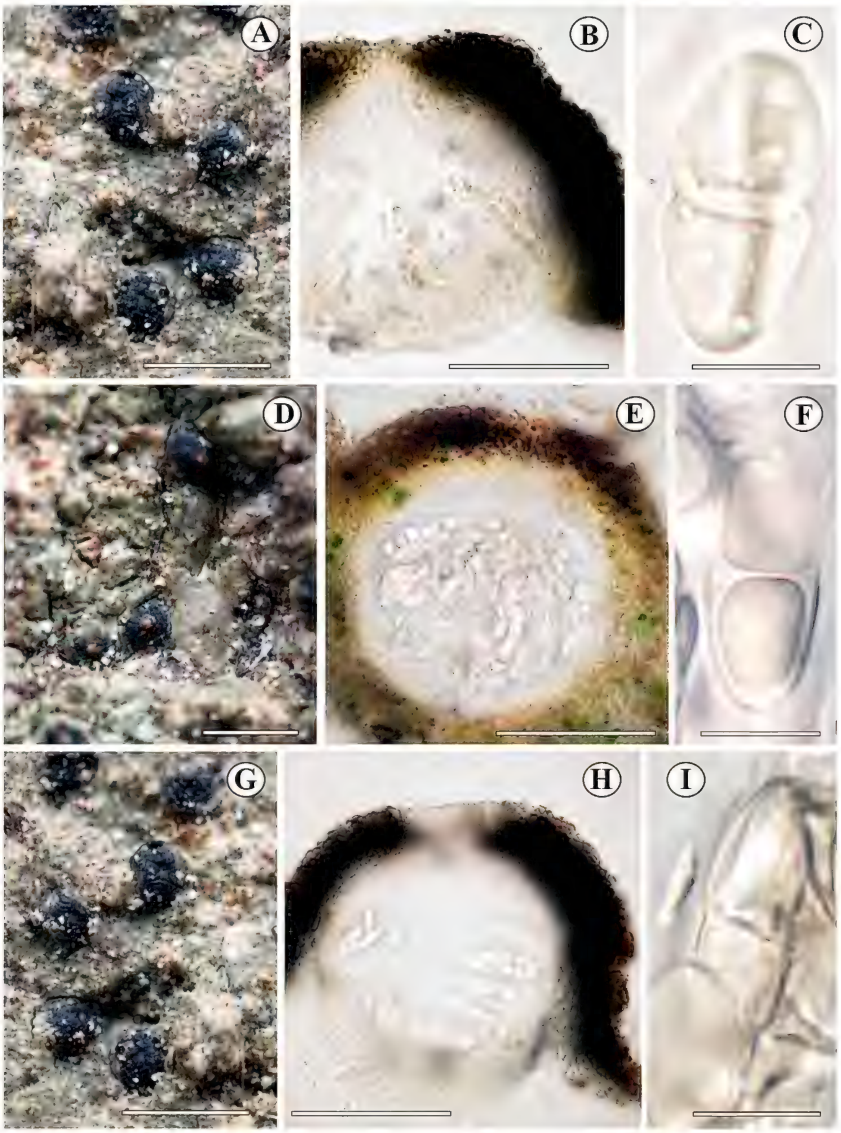

Plate 1. Pyrenocarpous lichens from South Korea: ***Thelidium japonicum*** (KoLRI 035223), A. thallus with ascomata; B. ascoma, vertical section; C. ascospores. ***Thelidium pluvium*** (KoLRI 035267), D. thallus with ascomata; E. ascoma, vertical section; F. ascospores. ***Thelidium radiatum*** (KoLRI 035288), G. thallus with ascomata; H. ascoma, vertical section; I. ascospores. Scale bars: A, D, G = 500 µm; B, E, H = 100 µm; C, F, I = 10 µm.

and *Pilophorus clavatus*. Our collections extend the range of *Thelidium japonicum* from Japan (Harada 1991) to South Korea.

Specimens examined—**SOUTH KOREA. Jeju-do, Jeju-si,** Halla Mts, Arail-dong, trail to Gwaneum Temple, 33°24′03″N 126°32′25″E, 868 m asl, on rock, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151530 (KoLRI 035223), 151533 (KoLRI 035226), 151545 (KoLRI 035238), 151550 (KoLRI 035243), 151553 (KoLRI 035246), 151554 (KoLRI 035247).

Comments—The Korean specimens agree with the type description by Harada (1991). *Thelidium japonicum* is most similar to *T. minutulum*, which differs by its grey-brown perithecial walls (Körber 1863) and its larger perithecia, absence of an involucrellum and more or less brownish exciple (Orange 2008).

Thelidium pluvium Orange, Lichenologist 23: 101 (1991) Pl. 3d–f

Saxicolous. Thallus slightly rimose, pale grey-green to dark brown, 35–85 µm thick. Photobiont green alga. Perithecia hemispherical, black, 220–400 µm diam.; ostiole conspicuous, prominent, not in a depression. Involucrellum rather thin, brown, K– or K + darker brown or greenish brown. Periphyses sparsely branched, 40 × 2–3 µm. Asci clavate, 8-spored, 75–100 × 25–30 µm. Ascospores ellipsoid, smooth, colourless, 1-septate, 23–36 × 9–16 µm, with numerous oily droplets when mature. Pycnidia not seen.

Ecology & distribution—The Korean material was found growing on basalt rocks associated with *Pilophorus clavatus*, and *Verrucaria margacea*. *Thelidium pluvium* occurs on siliceous and slightly basic rocks in streambeds and on dripping rocks in Europe, Asia, and Australia (Orange 1991, 2008); new to South Korea.

Specimen examined—**SOUTH KOREA. Jeju-do, Seogwipo-si,** Halla Mts, Yeongsil Trail, 33°21′16″N 126°29′58″E, 1337 m asl, on rock, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151574 (KoLRI 035267).

Comments—The Korean specimen agrees with the type description by Orange (1991). *Thelidium pluvium* is characterized by rather large perithecia covered by a layer of thallus except at dark apex, hyaline perithecial wall, and hyaline 1-septated ascospores. The otherwise similar *Thelidium pyrenophorum* and *T. methorium* differ in having a thick involucrellum and lacking a thalline cover on mature perithecia (Orange 2008).

Thelidium radiatum H. Harada, Hikobia 12: 133 (1996) Pl. 3g–i

Saxicolous. Thallus crustose, continuous, smooth, grayish green, margin not distinct. Perithecia black, hemispherical, 200–300 µm diam., without a

thalline cover, ± with cracks radiating around prominently depressed ostioles. Involucrellum appressed to exciple, ± extending to the perithecial base, 220–300 µm diam., 15–30 µm thick, dark brown to black. Exciple hyaline, 5–10 µm thick at base. Hymenium globose to depressed ovate, 100–200 × 140–230 µm. Upper periphyses simple, lower periphyses very sparsely branched, both 30–45 µm long. Asci clavate, 8-spored, 75 × 20 µm. Spores hyaline, oval, 1-septate, 22–27 × 8–11 µm. Pycnidia not seen.

Ecology & distribution—The Korean specimens were found growing on basalt rocks associated with *Agonimia pacifica*, *Pilophorus clavatus*, and *Verrucaria margacea*. Our collections extend the range of *Thelidium radiatum* from Japan (Harada 1996) to South Korea.

Specimens examined—**SOUTH KOREA. Jeju-do: Jeju-si,** Arail-dong, trail to Gwaneum Temple, 33°24′03″N 126°32′25″E, 868 m asl, on rock, 21 Jul. 2015, J.P. Halda, S. O.-Oh & D. Liu 151535 (KoLRI 035228), 151552 (KoLRI 035245); **Seogwipo-si,** Halla Mt., Yeongsil Trail, 33°21′19″N 126°29′59″E, 1353 m asl, 21 Jul. 2015, J.P. Halda, S.-O. Oh & D. Liu 151595 (KoLRI 035288).

Comments—The Korean material of *Thelidium radiatum* matches the type description by Harada (1996). The similar *T. japonicum* and *T. minutulum* are distinguished by their small perithecia that are dark brown to black at the base of perithecial walls and with projecting whitish ostioles, shorter ascospores, and the absence of an involucrellum. *Thelidium japonicum* is further distinguished from *T. radiatum* by forming granulose to areolate thallus. (Harada 1991).

Discussion

Moon (2013) confirmed 57 pyrenocarpous lichens from Korea, one third of which represented *Verrucaria* with boreal or cosmopolitan distribution. The largest (ca. 20%) percentage of *Verrucaria* recently reported from Korea is characterized by East Asian distribution. Islands between Korea and Japan represent important localities for lichens previously known only from type localities in Japan. Some species (e.g., *Verrucaria miyagiensis*) are in urgent need of serious taxonomic revision to establish their modern taxonomic relationships. Some East Asian representatives were described mainly from Japan (e.g., *Strigula maritima*, *Thelidium izuense*; Harada 2013, 2016) and China (*Thelidium yunnanum*; Harada & Wang 2004). The addition of an inconspicuous new species, *Thelenella haradae* from South Korea (Halda & Hur 2016) also illustrates that a number of pyrenocarpous lichens are still overlooked.

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Diploschistes wui sp. nov., an overlooked saxicolous lichen from Northwestern China

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Abstract—*Diploschistes wui* is described as a new species, based on three collections from Xinjiang in Northwestern China. It is characterized by a bluish gray and thin thallus, epruinose discs, small, 8-spored asci, and small ascospores. The new lichen resembles *D. rampoddensis* but is readily distinguished by the absence of surface crystals and pruinose discs. It grows on rocks at elevations above 1800 m. Our ITS rDNA sequence analyses support this species as independent.

Key words—biodiversity, central Asia, *Graphidaceae*, *Ostropales*, taxonomy

Introduction

The lichen-forming genus *Diploschistes* Norman includes crustose species with a blackish pseudoparenchymatous proper exciple, lateral paraphyses, and a trebouxioid photobiont (Lumbsch 1989, Lumbsch & Mangold 2007, Lumbsch & Huhndorf 2010). The genus is widely distributed in arid and semiarid regions worldwide, with c. 43–45 species (Kirk & al. 2008, Pérez-Vargas & al. 2012, Fernández-Brime & al. 2013, Abbas & al. 2014, Ababaikeli & al. 2016). Most *Diploschistes* species occur on rocks, some on soil, and a few species are occasionally found on wood or bark (Lumbsch & Mangold 2007, Ababaikeli

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& al. 2016). The genus exhibits a remarkable range in the morphology of the ascomata, varying from perithecioid to urceolate or lecanoroid (Lumbsch 1989, Lumbsch & Mangold 2007). Despite this variability, molecular studies support the genus as monophyletic within the *Graphidaceae* (Frisch & al. 2006, Martín & al. 2003, Fernández-Brime & al. 2013). The few phylogenetic studies on *Diploschistes* published to date (Lumbsch & Tehler 1998, Martín & al. 2003, Fernández-Brime & al. 2013, Zhao & al. 2017) investigated the taxonomic value of ascoma morphology for delimiting monophyletic entities both at the generic and species levels.

The lichen biota of Northwestern China is rich, with more than 750 species belonging to about 150 genera listed so far (Abbas & Wu 1998, Abbas & al. 2001, Guo 2005). Although its lichen diversity remains incompletely investigated, continuing surveys should reveal more new species from this region. Five of the ten *Diploschistes* species recorded from China were described from Northwestern China (Wei 1991, Guo 2005, Abbas & al. 2014, Ababaikeli & al. 2016).

A new *Diploschistes* species, recently collected from Xinjiang, Northwestern China, is described here as *D. wui*. A taxonomic study of the new species is presented, based on the morphological and chemical characters. ITS nrDNA sequences were obtained from the holotype and two other specimens were compared with sequences available in GenBank to assess the phylogenetic affinities of the new species.

Materials & methods

Specimens were collected from Bayi forest farm in Changji county, Urumqi city, Xinjiang, China, and have been deposited in the Herbarium Mycologicum Academiae Sinicae-Lichenes, Beijing, China (HMAS-L) and the Lichen Section of Botanical Herbarium, Xinjiang University, Urumqi, China (XJU). The morphology of the lichen specimens was examined using a Zeiss Stemi SV 11 stereomicroscope. Sections for anatomical examination were cut by hand using a razor blade and were mounted and observed in water. Anatomical structure and hymenial characters were studied with a Zeiss Axioskop 2 plus light microscope. The photos were taken with a Nikon Digital Camera D50. Chemical constituents were identified by thin-layer chromatography using solvent system C as described by Orange & al. (2010).

DNA extraction, amplification, sequencing

Thallus fragments with ascomata were removed from the holotype and two other specimens for DNA extraction, using the DNAsecure Plant DNA Kit following the manufacturer's protocol. Amplification of the ITS region followed the methods described in Martín & al. (2003) modified as in Abbas & al. (2014). The nrITS region (ITS1+5.8S+ITS2) of the nrDNA repeat tandem was amplified with the polymerase

chain reaction using primers ITS1 with ITS4 (White & al. 1990) in a 25 µL volume containing 0.75 units of TransStart Taq Polymerase, 2.5 µL ITS buffer, 0.5 µl 5 µM primer solution, 2 µL 2.5 mM for each dNTP solution, and 1 µL genomic DNA. Thermocycling protocols followed were: 95°C for 5 min followed by 35 cycles at 94°C for 30 s, 56°C for 30 s, and 72°C for 1 min, and ending with a final extension of 72°C for 10 min. PCR products were screened on 1% agarose gels stained with ethidium bromide, and were sequenced by Genewiz Inc. (Suzhou, China).

All newly obtained sequences were submitted to GenBank. Similarities were determined from Blast results of sequence data, morphological characters, and the literature (Martín & al. 2003; Fernández-Brime & al. 2013, 2015; Zhao & al. 2017). Newly generated sequences from the Xingjiang material were complemented with GenBank sequences representing the most similar taxa.

Phylogenetic analysis

The ITS sequences from our three specimens and the 14 GenBank representatives were aligned both by ClustalW and Muscle implemented in MEGA7 (Kumar & al. 2016). The final matrix, submitted to TreeBase, can be obtained from the corresponding authors.

The evolutionary history was inferred by using the Minimum Evolution method implemented in MEGA7 (Kumar & al. 2016). The evolutionary distances were computed using the Maximum Composite Likelihood method; units represented number of base substitutions per site. The rate variation among sites was modeled with a gamma distribution (shape parameter = 5). The Minimum Evolution (ME) tree was searched using the Close-Neighbor-Interchange (CNI) algorithm at a search level of 1. The initial tree was generated by the Neighbor-joining algorithm. The gaps were removed for each sequence pair. There were a total of 513 positions in the final dataset. The same dataset was also analyzed by Bayesian inference based on GTR model with rates = Invgamma.

Results & discussion

ITS sequences and the phylogenetic analysis

Almost the entire ITS region was successfully sequenced for the holotype and two additional specimens. Partial sequences (about 25 bp) were not obtained at the ITS1 5′ end, but partial sequences of the LSU 5′ end in region were included in the data submitted to GenBank (494, 495, and 480 bp in total).

The final nrITS alignment included 17 sequences representing 7 taxa and comprised 513 characters, of which 441 were constant, 18 were parsimony-uninformative, and 54 were parsimony-informative. There were no ambiguously aligned regions.

ITS sequence analysis places our specimens in either the *D. scruposus*-group (sensu Martín & al. 2003) or *D.* subg. *Diploschistes* (sensu Fernández-Brime

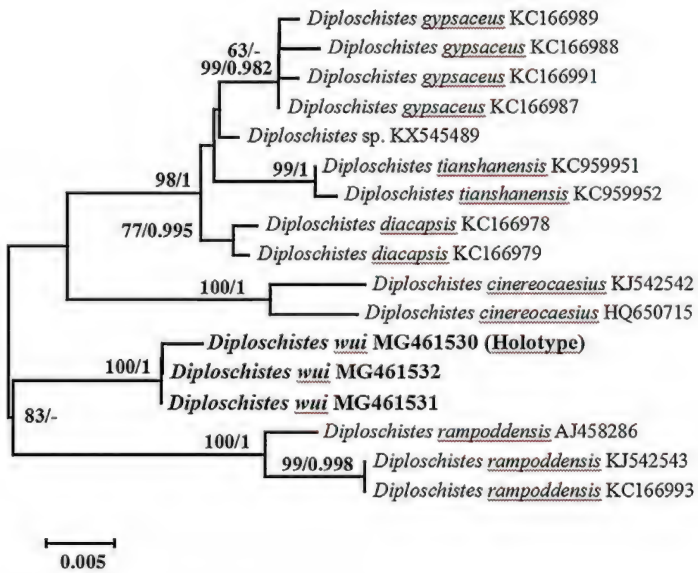

Fig. 1. An unrooted tree of 17 *Diploschistes* ITS sequences showing the phylogenetic relationships of *D. wui* and its closely related species. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. Bootstrap support ≥50% (BP; left) and posterior probabilities ≥0.95 (PP; right) are shown above branches. Newly generated sequences are presented in bold font. Internodes with both BP values ≥70% and PP ≥0.95 are highlighted by thicker lines.

& al. 2013) with close affinities to the pantropical species *D. rampoddensis* (93% identity and 2% gap). The evolutionary history was inferred as the minimum evolution tree (sum of branch length = 0.11303133). In the phylogenetic analysis, the relationship of the new species and its closely related species is clear (Fig.1).

Taxonomy

Diploschistes wui A. Abbas, S.Y. Guo & Ababaikeli, **sp. nov.** Fig. 2

FungalName FN 570518

Similar to *Diploschistes rampoddensis*, but distinguished by its thin, bluish gray thallus, its epruinose discs, its smaller 8-spored asci, and its smaller ascospores.

Type: China. Xinjiang: Urumqi, Changji County, Bayi forest farm, 43°22.82′N 86°48.22′E, alt. 1830 m, 3 Aug. 2009, A. Abbas 20093003 (**Holotype,** HMAS-L; GenBank MG461530; **Isotype,** XJU).

Etymology: The new species name honors Professor Jinong Wu, a pioneer Chinese lichenologist and lichenology advisor of author Abdulla Abbas.

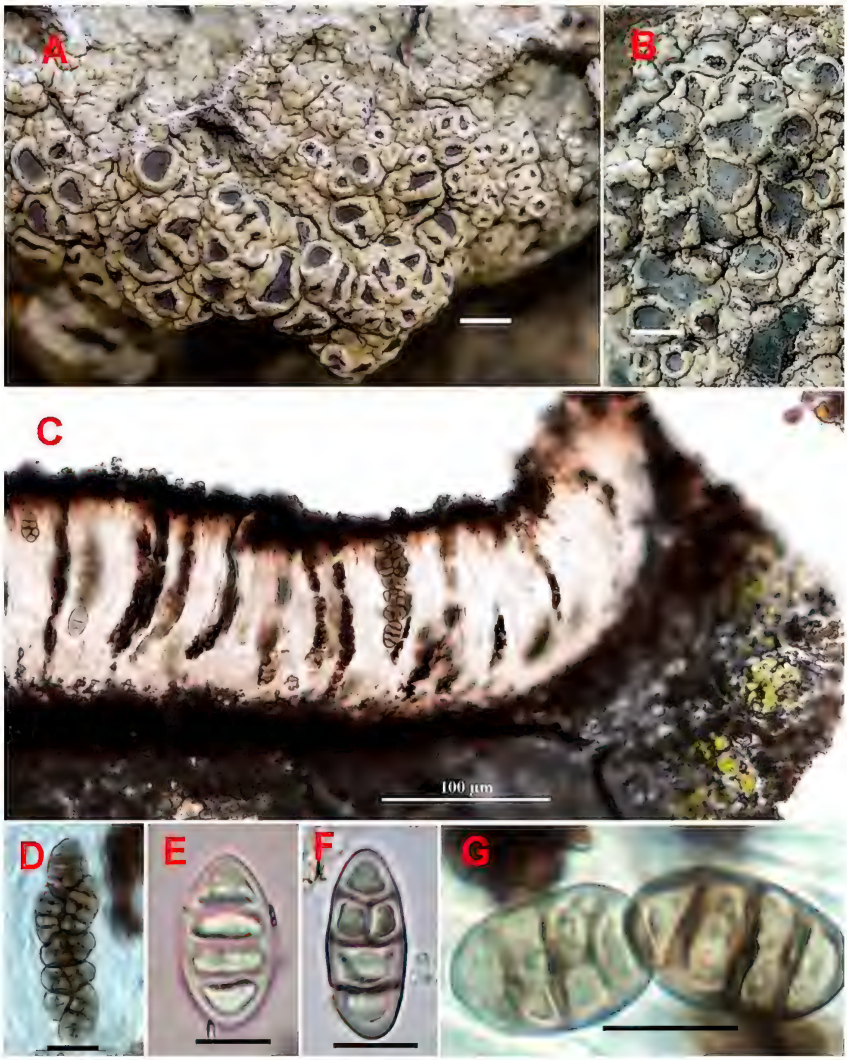

Fig. 2. *Diploschistes wui* (A, C–G = holotype, HMAS-L Abbas 20093003; B = XJU Abbas 20093004). A, B: general habit and ascomata; C: section through ascoma; D: ascus with ascospores; E–G: mature ascospores. Scale bars: A, B = 2 mm; C = 100 µm; D = 20 µm; E–G = 10 µm.

Thallus saxicolous, crustose, rimose-areolate, bluish grey to grayish white; areoles 0.3–0.6 mm diam., thin, usually <1.0 mm thick. Upper surface smooth, shiny or dull, epruinose. Medulla white. Photobiont trebouxioid with cells

≤10–13 µm diam. Prothallus not visible. Vegetative propagules absent. Ascomata apothecia, exposed. Disc urceolate, sessile, epruinose, blackish, concave, orbicular, 0.8–2.2 mm diam. Proper exciple dark brown, 60–80 µm thick. Hymenium hyaline, 80–100 µm high, not inspersed. Hypothecium yellowish brown, 20–40 µm thick. Paraphyses 1–2 µm thick, simple, apices not thickened. Asci cylindrical, 70–90 × 15–20 µm, 8-spored. Ascospores ellipsoid, brown, submuriform, with 3–5 transverse and 0–2 longitudinal septa, 10–15(–18) × 6–9 µm. Pycnidia unknown.

Spot tests—K–, C+ red, KC–, PD–, UV–.

Secondary metabolites—Only lecanoric acids detected by TLC.

Ecology—*Diploschistes wui* grows on rocks (mainly on flat surface of basic rocks). It is known only from the type locality in Xinjiang, Northwestern China, at elevation above 1800 m.

Additional specimens examined—**CHINA. Xinjiang: Urumqi,** Changji county, Bayi Forest farm, 43°22.82′N 86°48.22′E, alt. 1830 m, 15 July 2009, A. Abbas 20093004 (XJU; GenBank MG461531); 20093021(XJU; GenBank MG461532).

Comments—*Diploschistes wui* is very similar to the (6–)8-spored specimens of *D. rampoddensis* (Nyl.) Zahlbr., in both morphology and chemistry. However, *D. rampoddensis* differs in its grayish yellow to greenish yellow thallus with a crystalliferous surface, pruinose discs, and a usually pantropical distribution (Lumbsch 1993; Pant & Upreti 1993; Fernández-Brime & al. 2013, 2015).

The pantropical species *Diploschistes cinereocaesius* (Sw.) Vain., which resembles *D. wui* in its octosporous asci and somewhat similar ascospore size, is distinguished by its terricolous habit, larger apothecia that are usually secondarily subdivided, and a different chemistry, containing both lecanoric acid (major) and diploschistesic acid (minor) (Fernández-Brime & al. 2015). Another morphologically similar species with an epruinose thallus is *D. scruposus* (Schreb.) Norman., which differs in its (4–)8-spored asci and bigger ascospores (25–40 × 10–20 µm) (Ababaikeli & al. 2016).

A recent multilocus phylogeny of selected *Diploschistes* species demonstrated that only a few species in *D.* subg. *Diploschistes* are strongly supported as monophyletic, while *D. diacapsis*, *D. interpediens*, *D. muscorum*, *D. neutrophilus*, and *D. scruposus* are not monophyletic (Zhao & al. 2017). We feel that monophyly is a prerequisite for species recognition in single-locus ITS phylogenies. Other studies using DNA sequence data for species recognition in lichens support our opinion (e.g. Han & al. 2013, 2015; Abbas & al. 2014; Ababaikeli & al. 2016). Our morphological and phylogenetic analyses support recognition of *Diploschistes wui* as an independent species.

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Rhexoacrodictys broussonetiae sp. nov. from Guizhou, China

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Abstract—A new hyphomycete, *Rhexoacrodictys broussonetiae* is described and illustrated from specimens collected on dead *Broussonetia papyrifera* stems in Guizhou Province, China. It is characterized by distinct, unbranched conidiophores with monoblastic, percurrently extending conidiogenous cells that produce acrogenous, subspherical to spherical, 17–28 × 19–31 µm, 0–2 transversely septate conidia with several additional oblique longitudinal septa. A dichotomous key to the four *Rhexoacrodictys* species is provided.

Key words—*Acrodictys,* anamorphic fungi, *Ascomycota,* taxonomy

Introduction

Baker & Morgan-Jones (2002) established *Rhexoacrodictys* to accommodate four *Acrodictys* species: *R. erecta* (Ellis & Everh.) W.A. Baker & Morgan-Jones, *R. fimicola* (M.B. Ellis & Gunnell) W.A. Baker & Morgan-Jones, *R. fuliginosa* (B. Sutton) W.A. Baker & Morgan-Jones, and *R. queenslandica* (Matsush.) W.A. Baker & Morgan-Jones. Delgado (2009) later proposed the combination *R. martinii* (J.L. Crane & Dumont) G. Delgado, but Xia & al. (2017) transferred *R. martinii* to *Distoseptispora* and *R. queenslandica* to *Junewangia*, based on morphology and phylogenetic analysis. Thus, *Rhexoacrodictys* currently contains only three accepted species, which are mainly characterized by

indeterminate and regeneratively percurrently extending conidiogenous cells that often acquire a narrow circumscissile dehiscence zone at the extreme apex. The conidia, which are ellipsoid, ovoid, subspherical to spherical, transversely, longitudinally and obliquely septate, undergo rhexolytic conidial secession.

During ongoing surveys of saprobic microfungi from the subtropical forests of Guizhou Province, China, a *Rhexoacrodictys* specimen collected on dead stems of *Broussonetia papyrifera* was found to differ from all accepted *Rhexoacrodictys* taxa and is proposed here as a new species, *R. broussonetiae*. The holotype is deposited in the Mycological Herbarium of Zunyi Normal College, Zunyi, China (HMZNC).

Rhexoacrodictys broussonetiae Xiao X. Li & Z.J. Xiao, **sp. nov.** Fig. 1

FungalName FN570519

Differs from all other *Rhexoacrodictys* species by its subspherical to spherical conidia.

Type: China, Guizhou Province: Xishui National Nature Reserve, on dead stems of *Broussonetia papyrifera* (L.) Vent. (*Moraceae*), 27 Jun. 2017, X.X. Li (**Holotype**, HMZNC 0246).

Etymology: in reference to the host genus, *Broussonetia*.

Colonies on natural substrate effuse, hairy, brown to dark brown. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, cylindrical, smooth-walled hyphae, 2–4 µm diam. Conidiophores macronematous, mononematous, single or a loose cluster of 2–4, erect, straight or slightly flexuous, cylindrical, smooth, thick-walled, dark brown to blackish, 4–7-septate, 70–119 × 4.5–6.5 µm, inflated toward the base, 6.5–9 µm diam, blackish, tapering slightly, paler brown, indeterminate. Conidiogenous cells integrated, terminal, monoblastic, with a pale brown, narrow circumscissile dehiscence zone at the extreme apex, 3–4.5 µm diam, percurrently extending. Conidial secession rhexolytic. Conidia holoblastic, solitary, acrogenous, subspherical to spherical, with 0–2 transverse septa and several longitudinal and oblique septa, with darkly-pigmented bands over the septa, smooth, brown to dark brown, 17–28 × 19–31 µm, bearing a small marginal frill at the base, 2.5–4.5 µm diam, pale brown.

Comments—*Rhexoacrodictys broussonetiae* produces conidia that are similar in shape to those in *Distoseptispora martinii* (J.L. Crane & Dumont) J.W. Xia & X.G. Zhang, which differ in their (sub)globose to broadly ellipsoidal shape and smaller size (11–16 µm diam.—Delgado 2009; 15–20 × 11–16 µm—Xia & al. 2017). *Rhexoacrodictys broussonetiae* also differs from the other three *Rhexoacrodictys* species, which produce ellipsoid or ovoid conidia.

Fig. 1. *Rhexoacrodictys broussonetiae* (holotype, HMZNC 0246)
A. Conidiophores with conidia; B. Conidiophores and conidiogenous cells; C. Conidia.

Key to *Rhexoacrodictys* species

1. Conidia dictyosporous, subglobose to globose (17–28 × 19–31 µm, 0–2 transverse septa) ..... *R. broussonetiae*
1. Conidia dictyosporous, ellipsoid or ovoid 2
2. Conidia without a dark brown apex, more or less evenly pigmented (15–24 × 11–15 µm, 2–3 transverse septa, medium to blackish brown) ..... *R. fimicola*
2. Conidia apically dark brown to black, darker upwards when mature 3
3. Conidia 24–40 × 15–22 µm, septa predominantly oblique, dark brown or black ..... *R. erecta*
3. Conidia 21–26 × 12–16 µm, septa 3(–4) transverse, brown to blackish brown ..... *R. fuliginosa*

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Four interesting aphyllophoroid species in the tropical northern region of Veracruz, Mexico

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Abstract—The taxonomic study presents four aphyllophoroid fungi from the Tamiahua region of Veracruz in a tropical deciduous forest dominated by *Quercus oleoides*. *Gloeodontia discolor*, *Hydnochaete paucisetigera*, and *Thelephora dentosa* are recorded for the first time for Mexican mycobiota, and *Gloiothele lactescens* is reported for a new location.

Key words—*Basidiomycota*, clavarioid, corticioid, new records, taxonomy

Introduction

The 1260 ha of land known as Ejido Estero de Milpas (21°14′52″N 97°28′29″W) in the municipality of Tamiahua lies within the Tamiahua Lagoon region in northern Veracruz State, Mexico. The climate is tropical and the area is covered primarily by halophytic vegetation, cattle ranches, tall semi-evergreen forests, and an ecosystem in which tropical oaks are well represented, especially *Quercus oleoides* and *Q. glaucescens* (Registro Agrario Nacional 2016).

Aphyllophoroid fungi are an unofficial basidiomycete assemblage representing such diverse fungi as corticioids, polypores, and clavarioids (Kunttu & al. 2014); they are widely distributed in temperate and tropical forests and play an important role in the degradation of organic matter. This group includes terricolous, parasitic, and ectomycorrhizal species, although

little is known about them in the tropics of Mexico. Studies devoted to Mexican tropical aphyllophoroid fungi include Valenzuela & al. (2007, 2011, 2012a,b), Cifuentes & al. (2005), Raymundo & al. (2008, 2009), Medina-Jaritz & al. (2012), Ramírez-López & al. (2013), Ramos-Sosa & Cappello-García (2014), and Ávalos-Lázaro & al. (2016). Our recent survey of the mycobiota surrounding Tamiahua Lagoon in Veracruz, Mexico, revealed several interesting aphyllophoroid collections, described and illustrated below.

Materials & methods

Samples collected in the Ejido Estero de Milpas, municipality of Tamiahua, Veracruz, during July 2014 were described macroscopically from both fresh and dried material. Free-hand thin vertical sections of basidiocarps were mounted in 3% aqueous KOH, Melzer's reagent, Congo Red 1% aqueous solution, phloxine, Cotton blue, and/or sulfobenzaldehyde for microscopical examination using a light microscope. Drawings were made with the aid of a drawing tube. The specimens are preserved in the herbarium of Instituto de Ecología A.C., Xalapa, Veracruz, Mexico (XAL).

Taxonomy

Gloeodontia discolor (Berk. & M.A. Curtis) Boidin,
Cahiers de la Maboké 4 (1): 22 (1966) PLATES 1A; 2A–D

BASIDIOME annual, resupinate, adnate, effused, membranous, sometimes fimbriate under the lens, ≤20 cm lengthwise, thin, in section 30-70 µm thick excluding aculei, yellowish white to grayish yellowish, HYMENOPHORE odontoid to hydnoid, aculei usually slender, pointed at apex, ≤3.5 mm long.

HYPHAL SYSTEM dimitic; skeletal hyphae 1.5–3.5 µm diam., clamp-connections absent, yellowish, smooth, thick-walled (≤1.7 µm), becoming thin-walled and sometimes heavily encrusted with hyaline crystals at the apex in the aculei, non-amyloid, non-dextrinoid; generative hyphae 1–2.5 µm diam., with clamp connections, yellowish, smooth, thin to slightly thick-walled (≤0.8 µm), non-amyloid, non-dextrinoid. GLOEOCYSTIDIA (26–)28–80(–90) × (5–)6–10 µm, narrowly clavate-cylindrical to subulate, sometimes sinuous, with basal clamp connections, often with an apical bead, thin-walled, hyaline, turning dark blue to black on application of sulfuric acid in sulphovanillin. BASIDIA 15–22 × 3.5–4.5 µm, cylindrical, sometimes slightly sinuous, with a basal clamp, with four sterigmata. BASIDIOSPORES (3–)3.5–4.5 × 2.5-3 µm, ellipsoid to ovoid, sometimes adaxially flattened, with a slightly thickened wall, distinctly verrucose, pale yellow, strongly amyloid.

HABITAT—on dead wood of *Quercus oleoides* Schltdl. & Cham. in tropical (*Fagaceae*) deciduous forest; 6–25 m asl.

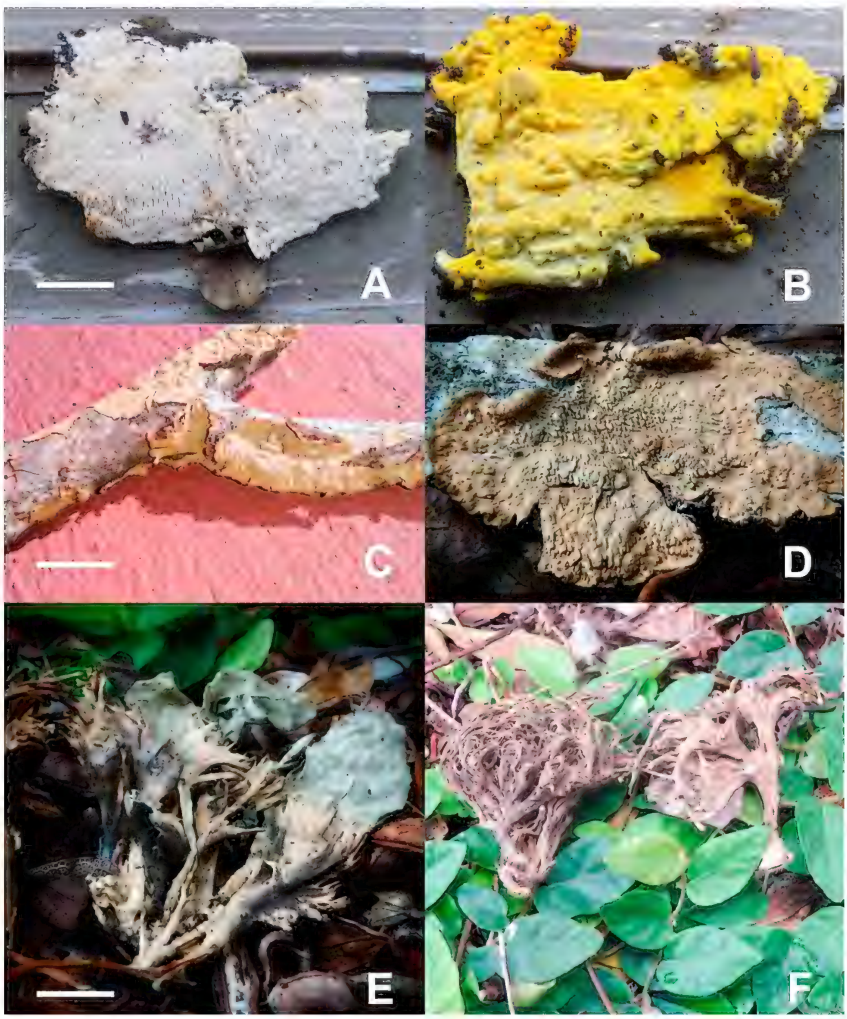


Plate 1. Basidiomata. A. ***Gloeodontia discolor***; B. ***Gloiothele lactescens***; C, D. ***Hymenochaete paucisetigera***; E, F. ***Thelephora dentosa***. Scale bars: A = 14 mm; B = 8 mm; C, E = 10 mm; D = 5 mm; F = 13 mm.

Specimen examined—**MEXICO, Veracruz State, Municipality of Tamiahua,** Ejido Estero de Milpas, 8 July 2014, F. Tapia & D. Jarvio 3149-B (XAL).

Remarks—The diagnostic characteristics of *Gloeodontia discolor*—resupinate, adnate, effused, odontoid to hydnoid hymenophore, sulpho-positive gloeocystidia measuring 35–70 × 6–10 µm, dimitic hyphal

system with incrusted hyphal ends, and basidiospores that are amyloid, verrucose, and 3.5–4.5(–5.5) × 2.5–3(–3.5) µm (Boidin 1966, Burdsall & Lombard 1976, Hjortstam & Ryvarden 2007)—match those observed for our material.

Macroscopically, *G. discolor* is somewhat similar to *G. columbiensis* Burt ex Burds. & Lombard, which differs by its shorter aculei (usually 0.5 mm long), monomitic hyphal system without clamp connections, and larger basidiospores (5.5–6.5 × 3.5–4(–4.5) µm; Burdsall & Lombard 1976). *Gloeodontia discolor* has been recorded from the subtropical to tropical regions of U.S.A., South America (Brazil, Venezuela), and Africa (Ivory Coast, Kenya, Tanzania) (Boidin 1966, Burdsall & Lombard 1976, Maekawa 1999, Hjortstam & Ryvarden 2007, Zhou & Dai 2013). Our collection represents the first record of *G. discolor* from Mexico.

Gloiothele lactescens (Berk.) Hjortstam, Windahlia 17: 58 (1987) PLATES 1B; 2E–H

≡ *Corticium lactescens* (Berk.) Berk., Outl. Brit. Fung.: 274 (1860)

≡ *Gloeocystidiellum lactescens* (Berk.) Boidin, Compt. Rend. Hebd. Séances Acad. Sci., Paris: 1668 (1951)

≡ *Vesiculomyces lactescens* (Berk.) Boidin & Lanq., Mycotaxon 16: 493 (1983)

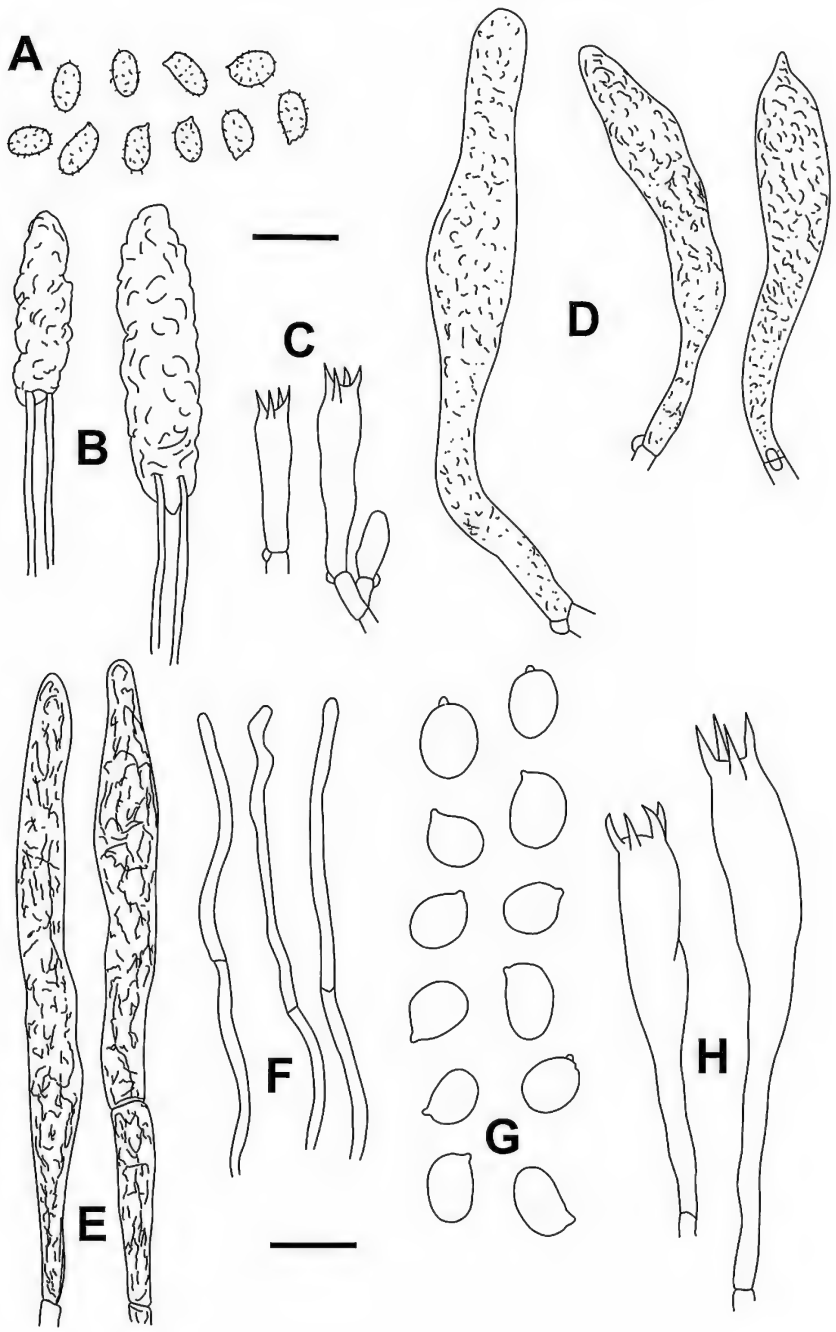
HABITAT—On dead wood of *Licaria capitata* (Cham. & Schlecht.) Kosterm. (*Lauraceae*), in tropical deciduous forest; 6–25 m asl.

SPECIMEN EXAMINED—**MEXICO, VERACRUZ STATE, Municipality of Tamiahua,** Ejido Estero de Milpas, 8 July 2014, F. Tapia & D. Jarvio 3159 (XAL).

REMARKS—Our new Mexican specimen of *G. lactescens* was readily identified by its larger, sinuous gloeocystidia (sometimes septate from the middle to the base); basidiospores that are weakly amyloid, smooth, broadly ellipsoid, 6.5–8 × 4.5–6.5 µm; and hymenium with numerous paraphysoid hyphae. Those characters—together with the resupinate, adnate, effused basidiome, whitish or watery gray to yellow or pale straw yellow hymenial surface that is ceraceous and slightly hygrophanous, and cracked dried older specimens—match the descriptions of Eriksson & Ryvarden (1975, as *Gloeocystidiellum lactescens*), Maekawa (1994, as *Vesiculomyces lactescens*), Ginns & Freeman (1994), Wu (1996), Boidin & al. (1997), and Bernicchia & Gorjón (2010).

Gloiothele lactescens is morphologically similar to *G. tropicalis* (Burds. & al.) Ginns & G.W. Freeman, distinguished by its narrower (4–5 µm) basidiospores, and *G. citrina* (Pers.) Ginns & G.W. Freeman, which differs

PLATE 2. ***Gloeodontia discolor*** A. basidiospores; B. encrusted hyphae; C. basidia; D. gloeocystidia. ***Gloiothele lactescens*** E. gloeocystidia; F. paraphysoid hyphae; G. basidiospores; H. basidia. Scale bars: A–D = 4.5 µm; E–H = 6 µm.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by its larger (7.6–8.8 × 5.8–7.0 µm) basidiospores; both *G. tropicalis* and *G. citrina* are further distinguished by having no to few hyphidia (Ginns & Freeman 1994).

According to Freeman (1978), *G. lactescens* is widely distributed in many temperate and subtropical regions of the world, mainly in Europe, North America, and Taiwan. Burt (1926) originally reported the species from Mexico (as *Corticium lactescens*) from inland central Veracruz state, and Welden & Lemke (1961) and Guzman (1975) recorded *G. lactescens* from Nuevo León state; here we report it from a new locality, northern coastal Veracruz state.

Hymenochaete paucisetigera (Parmasto & Sheng H. Wu) S.H. He & Y.C. Dai, Fungal Diversity 56: 90 (2012) PLATES 1C–D; 3A–E

≡ *Hydnochaete paucisetigera* Parmasto & Sheng H. Wu, Mycotaxon 91: 461 (2005)

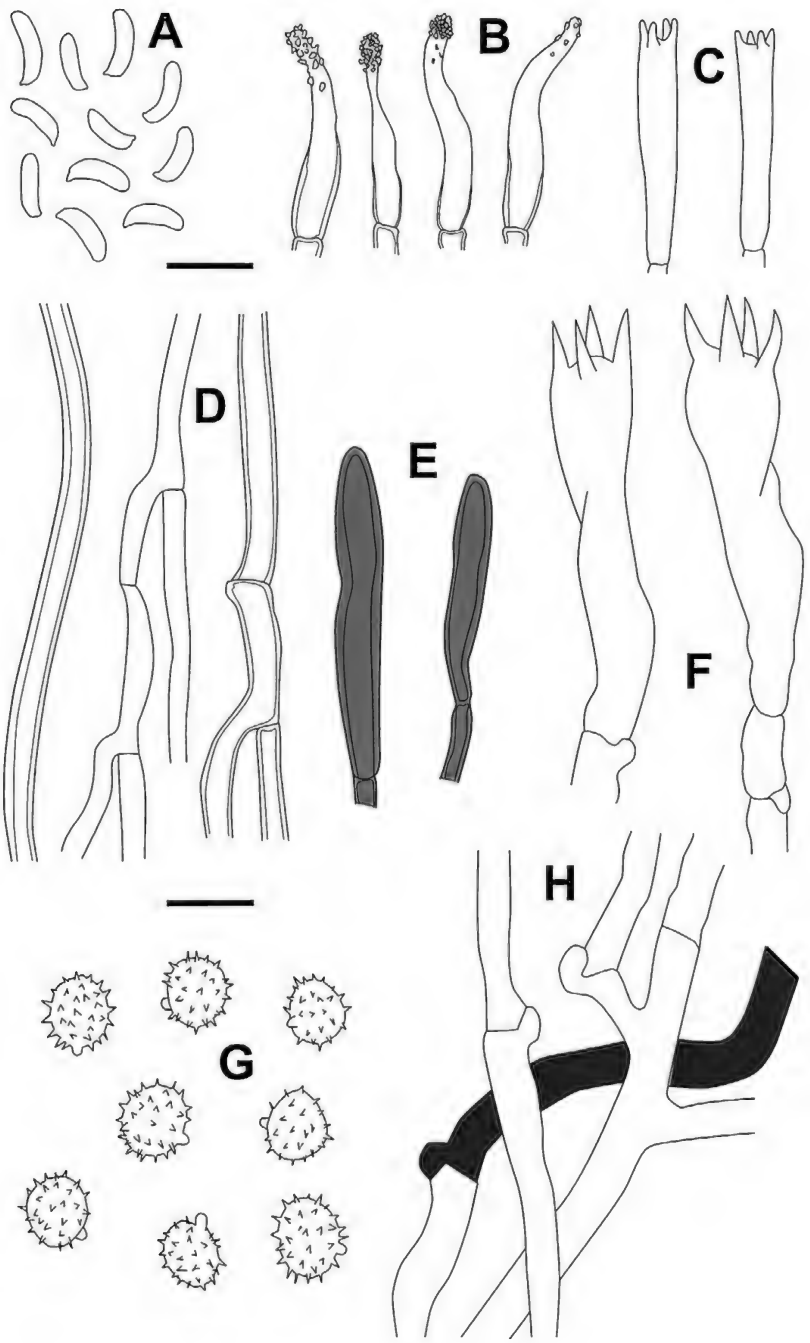
BASIDIOME annual, resupinate, effused-reflexed to pileate, sometimes imbricate, flexible, coriaceous or woody hard. PILEI semicircular to conchate, lifted ≤0.7 mm, ≤2 cm wide, 0.5–1 mm thick, with wavy margin. PILEAL SURFACE dark umber to dark brown, velutinous to tomentose, with concentric zones. HYMENOPHORE hydnoid, pale tan, buff-yellow, or yellowish brown, olive-tinged when dry; aculei irregularly shaped: slightly flattened, tapered, or cylindrical; often solitary, some confluent, 0.5–1.5 mm long. CONTEXT thin, ≤1.5 mm thick, separated from tomentum by a thin black line.

TOMENTUM well developed, 70–180 µm thick; cortex present, ≤40 µm thick; hyphal layer ≤200 µm thick. HYPHAL SYSTEM dimitic; generative hyphae simple septate, hyaline to pale yellowish, thin to slightly thick walled, often branched, 1.5–3.5 µm diam; skeletal hyphae yellow to yellowish brown, thick-walled, 2.5–4 µm diam. SETAE very rare, confined to the hymenium, dark brown, distinctly thick-walled, with blunt tips, 24–40 × 4–7(–9) µm. HYPHIDIA abundant, 15–20 × 1.5–3 µm, hyaline pale to yellowish, thin-walled, tips occasionally encrusted with small resinous granules. BASIDIA 12–25 × 3–4.5 µm, clavate, with four sterigmata. BASIDIOSPORES 4–5(–5) × 1.2–1.8(–2) µm, narrowly cylindrical, curved, hyaline, inamyloid, thin-walled, smooth.

HABITAT—On branches of *Quercus oleoides* in tropical deciduous forest; 4–25 m asl.

SPECIMEN EXAMINED—**MEXICO, VERACRUZ STATE, Municipality of Tamiahua,** Ejido Estero de Milpas, 9 July 2014, F. Tapia & D. Jarvio 3171-B (XAL).

PLATE 3. ***Hymenochaete paucisetigera*** A. basidiospores; B. hyphidia; C. basidia; D. generative and skeletal hyphae; E. setae. ***Thelephora dentosa*** F. basidia; G. basidiospores; H. generative hyphae. Scale bars: A–D = 4 µm; E = 6.5 µm; F–H = 5.5 µm.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Remarks—Although *Hymenochaete paucisetigera* was originally described in *Hydnochaete* by Parmasto & Wu (2005), morphological and sequence analyses by He & Dai (2012) demonstrated that the species is phylogenetically more closely related to *Hymenochaete*.

Hymenochaete paucisetigera, which is diagnosed primarily by its effused-reflexed to pileate basidiocarp and very rare setae, may be confused with *H. asetosa* (Y.C. Dai) S.H. He & Y.C. Dai, which differs by its larger (5–6 × 2.8–3.3 μm) basidiospores and the absence of setae (Dai 2010, as *Hydnochaete asetosa* Y.C. Dai). Macroscopically, *H. paucisetigera* is also very similar to *Hymenochaetopsis tabacinoides* (Yasuda) S.H. He & Jiao Yang, which differs by its abundant setae and a predominantly pileate basidiome and rarely effused-reflexed (Dai, 2010 as *Hydnochaete tabacinoides* (Yasuda) Imazeki). The Mexican material agrees with the descriptions of *H. paucisetigera* (previously known only from Taiwan on dead *Carpinus* sp. trees) by Parmasto & Wu (2005) and Dai (2010). Tapia & al. (2016) listed Mexican records of three hydnoid *Hymenochaete* species; our new record of *H. paucisetigera* adds a fourth.

Thelephora dentosa Berk. & M.A. Curtis, Journal of the Linnean Society, Botany 10: 329 (1868 ["1869"]) Plates 1E–F; 3F–H

Basidiome initially encrusting with irregular shapes (sometimes rhizomorphic) or easily separable patches, developing erect or oblique processes (0.2–5 × 0.2–3.5 cm) that are narrowly clavarioid, ramiform, or spathulate, often with subulate lobes (both processes and lobes regularly present); stipe 0.3–2 × 0.1–0.2 cm. Hymenium amphigenous. Hymenophore smooth to finely velutinous, dark brown to brownish umber with purplish tinge, slightly to distinctly cyanescent in KOH. Flesh thin, soft, beige to pallid brown.

Hyphal system monomitic; generative hyphae with clamp connections, thin to slightly thick-walled, sometimes branched, interwoven, 3–6(–7) μm diam, walls colorless or pale brown. Hymenium slightly to distinctly cyanescent in KOH. Cystidia none, but cystidioid lageniform elements (19–36 × 4.5–7.5 μm) sometimes present. Basidia 40–65 × 8–10 μm, clavate to subclavate, sometimes subcylindrical, 4-spored, clamped, often yellowish to hyaline in KOH. Basidiospores 7–8(–9) × 6.5–8 μm, yellowish brown, subglobose or broadly ellipsoid, each with a blunt apiculus, echinulate with 1-μm long spines.

Habitat—On dead twigs and leaves and encrusting parts of living plants in tropical deciduous forest; 4–25 m asl.

Specimens examined—**MEXICO, Veracruz State, Municipality of Tamiahua,** Ejido Estero de Milpas, 7 July 2014, F. Tapia & D. Jarvio 3125; 3126 (XAL); 9 July 2014, F. Tapia & D. Jarvio 3179 (XAL).

Remarks—The Mexican specimens match perfectly with descriptions of *Thelephora dentosa* by Burt (1914), Corner (1968), Welden (1968), and Stalpers (1993). This species is characterized by its resupinate growth (or resupinate with more or less clavarioid excrescences), subglobose basidiospores, and hymenium that is cyanescent in KOH. Immature basidiomata of *T. dentosa* found only on encrusting leaves and twigs and lacking clavarioid processes, might be confused with *T. atra* Weinm., *T. crustacea* Schumach., *T. spiculosa* (Fr.) Fr., and *T. penicillata* (Pers.) Fr., all species that differ in having basidiospores larger than 9 µm (Corner 1968, Stalpers 1993). Temperate species with stereoid basidiomata (e.g., *T. terrestris* Ehrh., *T. griseozonata* Cooke) have also been reported to adhere to living plant matter (Cunningham 1957, Corner 1968, Watling 1996).

In Jalisco, Mexico, Ramírez-López & al. (2013), who studied the phenotypic variations of a *Thelephora* sp. exhibiting the same growth as *T. dentosa*, showed that developing or growing clavarioid basidiomata can become resupinate when in contact with rocks, leaf litter, or live plants, sometimes forming groups of up to 139 basidiomata over an area of 30 m^2.

Thelephora dentosa is known from Cuba, Haiti, and Jamaica (Burt 1914, Welden 1968, Corner 1968); here it is recorded for the first time in Mexico.

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Buellia taishanensis sp. nov. and new *Buellia* records from Mt. Tai, China

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Abstract—Four species of the lichen genus *Buellia* are reported from Mt. Tai, Shandong, China. *Buellia taishanensis* is described as a new species, *B. chujana* and *B. halonia* are new to China, and *B. badia* has previously been reported from China. Descriptions are presented with morphological and chemical characters. After revising identifications from previous reports, we provide notes and a key to the four *Buellia* now confirmed from Mt. Tai.

Key words—*Ascomycota*, *Lecanoromycetes*, *Caliciales*, *Caliciaceae*, taxonomy

Introduction

Buellia De Not. (*Caliciaceae*, *Caliciales*, *Lecanoromycetidae*, *Lecanoromycetes*, *Pezizomycotina*, *Ascomycota*) is a cosmopolitan genus of lichenized fungi represented by more than 450 species (Kirk & al. 2008, Watanuki & al. 2017) and characterized by a crustose thallus, lecideine apothecia with black discs, a brown hypothecium, and brown septate ascospores.

Fifty *Buellia* species have previously been reported in China (Wei 1991, Aptroot & Seaward 1999, Aptroot & Sipman 2001, Aptroot & Sparrius 2003, Obermayer & al. 2004, Kondratyuk & al. 2013, Liu & Wei. 2013, Sun & al. 2013). During our study of *Buellia* from Mt. Tai, a world famous natural and cultural heritage, we collected a new species, described here as *Buellia taishanensis*, and recorded *B. chujana* and *B. halonia* as new to China.

Materials & methods

Specimens. All examined materials were collected from Mt. Tai, Shandong Province, and are deposited in Lichen Herbarium of the College of Life Sciences, Liaocheng University, Liaocheng, China (LCU). Morphological examinations were conducted following protocols set forth in Jia & Wei (2016).

DNA extraction, amplification, and sequencing. DNA was extracted from ascomata and thallus fragments using the DNAsecure Plant DNA Kit following the manufacturer's protocol. The ITS1+5.8S+ITS2 nrDNA region was amplified using the ITS1F and ITS4 primers (White & al. 1990, Gardes & Bruns 1993) in 25 µL volumes containing 12.5 µL 2×Taq PCR MasterMix, 1 µL 10µM solution of each primer, 0.5 µL genomic DNA, and 10 µL ddH_2O. Thermocycling parameters comprised initial denaturation at 94°C for 3 min, 35 cycles of denaturation at 94°C for 30 s, annealing at 54°C for 30 s, extension at 72°C for 1 min, and a final extension at 72°C for 5 min. The PCR products were screened on 1% agarose gels stained with ethidium bromide and sequenced using a ABI 3700 Sequencer. Newly generated sequences were submitted to GenBank.

Taxonomy

Buellia taishanensis Q.D. Wang & Z.F. Jia, **sp. nov.** Pl. 1

Fungal Name FN570500

Differs from *Buellia concinna* by its smaller ascospores and the absence of gyrophoric, lecanoric, and orsellinic acids.

Type: China. Shandong Province, Taian City, Mt. Tai, Jade Emperor Summit, 36°15′N 117°06′E, alt. 1510 m, 23/VIII/2017, Q.D. Wang TS1745 (**Holotype**, LCU; GenBank MG250190).

Etymology: The specific epithet *taishanensis* refers to the type locality of the new species, Mt. Tai (Taishan).

Thallus saxicolous, crustose, grey or grey-brown; thin or lacking cortex; surface rough and non-pruinose; medulla white.

Apothecia lecideine, often abundant, sessile; disc black, epruinose, at first plane, marginate, later becoming convex, thinly marginate, 0.5–0.8 mm diam; exciple *aethalea*-type, 15–35 µm thick; epithecium brown, 10–15 µm; hymenium 40–60 µm tall, hyaline, without oil droplets, paraphyses 1.5–2.5 µm diam; hypothecium dark brown. Asci cylindrical to clavate, 25–45 × 9–15 µm, 8-spored. Ascospores brown to dark brown, *Buellia*-type, ellipsoid, 1-septate, 10–12 × 4–5 µm. Pycnidia not observed.

Chemistry: Norstictic acid (by TLC).

Additional specimen examined: **China. Shandong Province, Taian City,** Mt. Tai, Jade Emperor Summit, alt. 1510 m, 23/VIII/2017, Q.D. Wang TS1751 (LCU).

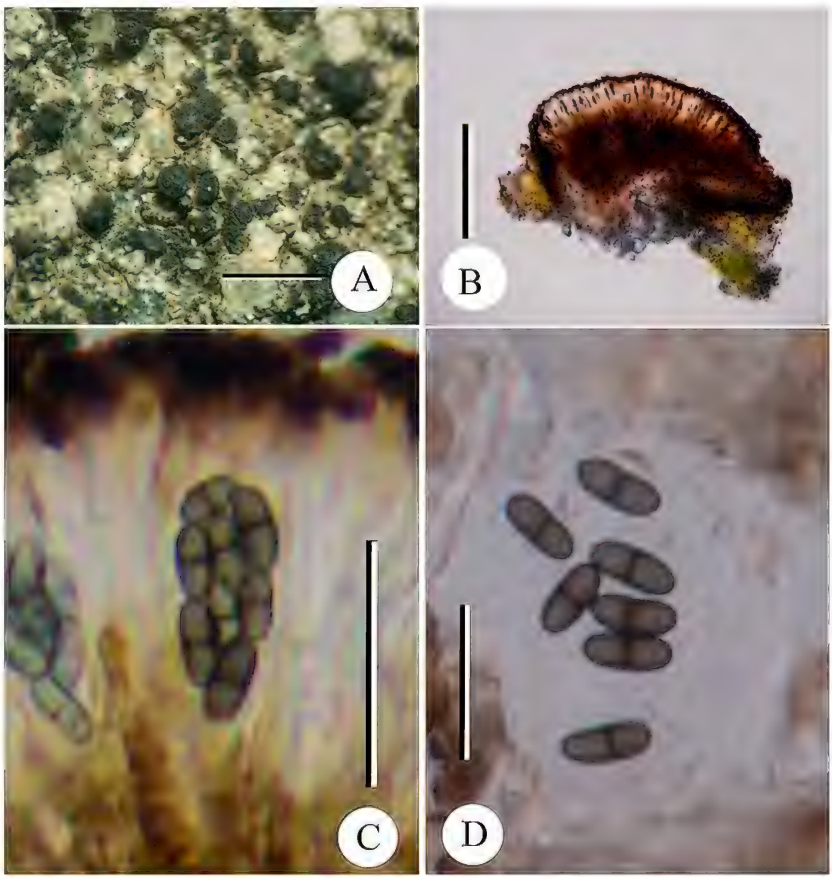

Plate 1. *Buellia taishanensis* (holotype, LCU Wang TS1745). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus containing ascospores; D. Ascospores. Scales: A = 2 mm; B = 100 µm; C = 50 µm; D = 20 µm.

Remarks: *Buellia taishanensis* is morphologically similar to *Buellia concinna* Th. Fr., which can be distinguished by its larger (15–21 × 7–9 µm) ascospores and production of gyrophoric, lecanoric, and orsellinic acids (Bungartz & al. 2004).

Buellia badia (Fr.) A. Massal., Mem. Lichenogr.: 124 (1853).

Thallus saxicolous, crustose, bullate to subsquamulose (becoming distinctly squamulose), continuous; surface deep brown, smooth, epruinose; medulla white.

Apothecia lecideine, 0.3–0.7 mm diam, sessile; disc black, epruinose, initially plane, usually becoming strongly convex; exciple narrow, *aethalea*-type, 15–40 µm thick; epithecium brown, hymenium 50–75 µm tall, hyaline, without oil droplets, paraphyses 2–3 µm diam. Asci cylindrical to clavate, 8-spored. Ascospores brown to dark brown, *Bacidia*-type, ellipsoid, 1-septate, 12–15 × 6–8 µm. Pycnidia not seen.

Chemistry: No lichen compounds detected by TLC.

specimen examined: **CHINA. Shandong Province, Taian City,** Mt. Tai, Hurrahing Gate, alt. 850 m, 23/VIII/2017, Q.D. Wang TS1777 (LCU; GenBank MG250192).

Remarks: Our Chinese specimen of *Buellia badia* has very slightly larger ascospores in the lower range than previously described (10–15 × 5–8 µm; Bungartz & al. 2007) but otherwise has similar morphology and chemistry. *Buellia badia* shares a similar chemistry with *B. imshaugii* Hafellner, which differs by its grayish brown thallus and *dispersa*-type exciple. *Buellia badia* has been reported from Europe, North Africa, North America, South Korea, and New Zealand (Scheidegger 1993, Bungartz & al. 2004, Wang & al. 2016). In China, the lichen has previously been reported in Liaoning, Heilongjiang, and Taiwan (Kondratyuk & al. 2013, Qi & al. 2015, Aptroot & Sparrius 2003); new to Shandong.

Buellia chujana Xin Y. Wang, S.Y. Kondr., L. Lökös & J.S. Hur, Mycobiology 44(1): 16 (2016). Pl. 2

Thallus saxicolous, crustose, rimose, continuous; brown or dark brown; areoles 0.2–0.8 mm across, with a clear thallus margin, surface smooth and non-pruinose, medulla white.

Apothecia often abundant; disc black, epruinose, plane convex; 0.1–0.5 mm diam., immersed to sessile; exciple narrow, 15–40 µm thick; epithecium brown; hymenium 30–50 µm tall, hyaline, without oil droplets, paraphyses 2–3 µm diam. Asci cylindrical to clavate, 8-spored. Ascospores brown to dark brown, *Bacidia*-type, ellipsoid, 1-septate, 8–11 × 6–8 µm. Pycnidia not seen.

Chemistry: Perlatolic acid (by TLC).

Selected specimens examined: **CHINA. Shandong Province, Taian City,** Mt. Tai, Houshiwu, alt. 1300 m, 23/VIII/2017, Q.D. Wang TS1767 (LCU; GenBank MG250191); Shanziya, alt. 590 m, 28/X/2006, Y.N. Hou TS1010 (LCU); Linghan Peak, alt. 300 m, 13/V/2007, J. Li TS1040 (LCU); Hongdelou, alt. 1510 m, 8/X/2008, C.M. Wang TS1323, C.C. Jin TS1324 (LCU); Tianzhu Peak, alt. 750 m, 8/XI/2008, M.H. Cao TS1354 (LCU); Aolai Peak, alt. 550 m, 3/XI/2011, R.C. Ren TS1440 (LCU); Tianzhu Turtle, alt. 980 m, 23/VIII/2017, Q.D. Wang TS1772, TS1774 (LCU); Hurrahing Gate, alt. 850 m, 23/VIII/2017, Q.D. Wang TS1778 (LCU).

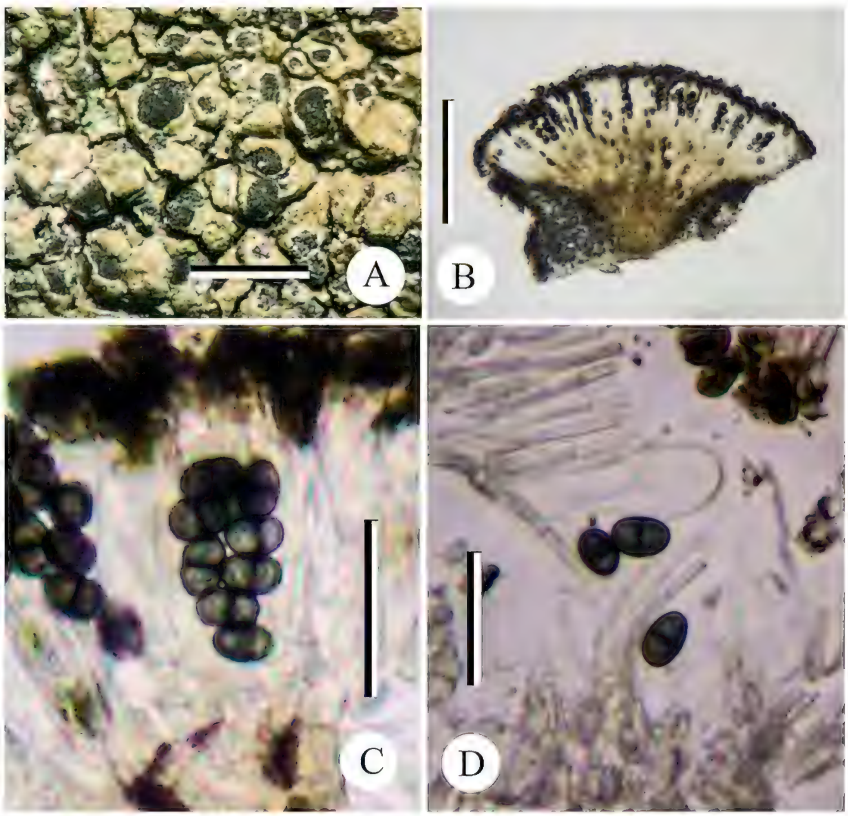

Plate 2. *Buellia chujana* (LCU Wang TS1767). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus containing ascospores. D. Ascospores. Scales: A = 1 mm; B = 100 µm; C = 50 µm; D = 20 µm.

Remarks: Our Chinese specimen of *Buellia chujana* has a thinner hymenium than previously described (50–60 µm; Wang & al. 2016), but otherwise has similar morphology and chemistry. *Buellia chujana* is morphologically similar to *B. nashii* Bungartz, which can be distinguished by its subsquamulose thallus containing atranorin and norstictic acid as the main compounds. Previously known only from South Korea (Wang & al. 2016), *B. chujana* is new to China.

Buellia halonia (Ach.) Tuck., Lich. Calif.: 26 (1866). Pl. 3

Thallus saxicolous, crustose, rimose; areoles yellowish green to pale yellow; thallus surface smooth and epruinose.

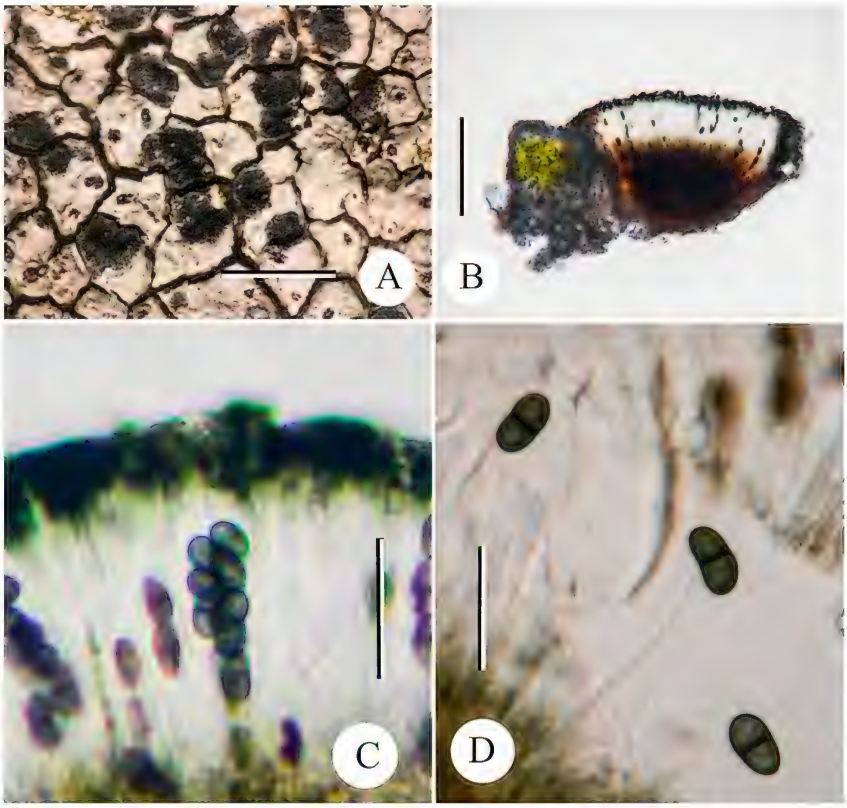

Plate 3. *Buellia halonia* (LCU Wang TS1749). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus containing ascospores. D. Ascospores. Scales: A = 1 mm; B = 100 µm; C = 50 µm; D = 20 µm.

Apothecia epruinose; disc black, plane, initially immersed, soon bursting through thallus surface and becoming adnate to sessile, 0.2–0.5 mm diam; exciple 25–50 µm thick; epithecium brown; hymenium 40–60 µm tall, hyaline, without oil droplets, paraphyses 2–3 µm diam. Asci cylindrical to clavate, 8-spored, *Bacidia*-type. Ascospores initially olive, brown at maturity, oblong to ellipsoid, 1-septate, 13–15 × 6–8 µm. Pycnidia not seen.

Chemistry: Atranorin and norstictic acid (by TLC).

Specimen examined: **CHINA. Shandong Province, Taian City,** Mt. Tai, Jade Emperor Summit, alt. 1510 m, 23/VIII/2017, Q.D. Wang TS1749 (LCU; GenBank MG250193).

Remarks: The morphology and chemistry of our Chinese specimen agrees with that described by Bungartz & al. (2004). *Buellia halonia* is morphologically similar to *B. mamillana* (Tuck.) W.A. Weber, which differs by its pruinose thallus with norstictic and connorstictic acid as the main compounds. Previously known from North America, South Africa, Australia, Chile, and South Korea (Bungartz & al. 2004, 2007; Wang & al. 2016), *B. halonia* is new to China.

Notes on previous reports of *Buellia* from Mt. Tai

Four *Buellia* species previously reported from Mt. Tai by Sun & al. (2013) are revised as follows: *B. atrocinerella* (Nyl.) Scheid. represents a misdetermination and is revised here as *B. chujana;* specimens TS1324 and TS1354 (previously cited under *B. centralis*) are redetermined here as *B. chujana,* while specimen TS231 must still be tested for the presence of norstictic acid; and the specimens cited as representing *B. ocellata* (Flörke ex Flot.) Körb. and *B. spuria* (Schaer.) Anzi possess lecanorine apothecia and must be referred to a different lichen genus.

Key to the species of *Buellia* from Mt. Tai

1a. Ascospores <12 µm long 2
1b. Ascospores >12 µm long 3
2a. Norstictic acid present; ascospores 10–12 × 4–5 µm ..... *B. taishanensis*
2b. Perlatolic acid present; ascospores 8–11 × 6–8 µm ..... *B. chujana*
3a. Lichen compounds absent ..... *B. badia*
3b. Atranorin and norstictic acid present ..... *B. halonia*

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Replacement names for two Australian species of *Inocybe*

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Abstract—Replacement names are proposed for two Australian *Inocybe* species that are illegitimate later homonyms: *I. austrofibrillosipes* for *I. fibrillosipes* Matheny & al. and *I. fulvotomentosa* for *I. mallocyboides* Matheny & al.

Key words—*Agaricales*, *Inocybaceae*, new names, nomenclature

Inocybe austrofibrillosipes Matheny, Bougher & G.M. Gates **nom. nov.**

MycoBank MB 824698

Etymology—Referring to *I. fibrillosipes* of the southern hemisphere.

≡ *Inocybe fibrillosipes* Matheny, Bougher & G.M. Gates, Fungi of Australia: *Inocybaceae:* 188. June 2017, nom. illegit. ICN Art. 53.1
[non *I. fibrillosipes* E. Ludw., Pilzkompendium 4: 394. April 2017.]

Type: Australia, Tasmania, Mount Field National Park Lady Barron Track, gregarious to scattered in wet sclerophyll forest along bank of track under *Eucalyptus regnans*, *Acacia,* and *Pomaderris*, 8 June 2009, leg. D. Ratkowsky, G. Gates & P.B. Matheny PBM3224 (holotype, PERTH 08517002; isotype TENN 068200; GenBank ITS KJ778858).

Inocybe fulvotomentosa Matheny, Bougher, R. Rob. & K. Syme **nom. nov.**

MycoBank MB 824699

Etymology—Referring to the yellowish brown colors and tomentose pileus surface.

≡ *Inocybe mallocyboides* Matheny, Bougher, R. Rob. & K. Syme, Fungi of Australia: *Inocybaceae*: 180. June 2017, nom. illegit. ICN Art. 53.1
[non *I. mallocyboides* E. Ludw., Pilzkompendium 4: 434. April 2017.]

Type: Australia, Western Australia, London Forest Block, 1.8 km south of Mountain Road, along Renzo Road extension, on sandy soil in Jarrah forest under *Eucalyptus marginata*, *Kunzea,* and other myrtaceous shrubs, 10 June 2010, leg. R.M. Robinson & K. Syme PBM3501 (holotype, PERTH 08242240; isotype TENN 069669; GenBank ITS KP308773).

Two major works documenting species of *Inocybaceae* Jülich were published during 2017, one in Australia (Matheny & Bougher 2017) and one in Europe (Ludwig 2017). Both works independently described two new species under the names *Inocybe fibrillosipes* and *I. mallocyboides;* the European species in Ludwig (2017) are taxonomically unrelated to their Australian homonyms in Matheny & Bougher (2017). Because the study by Ludwig was published in April 2017 and that of Matheny & Bougher in June 2017, the names presented by Matheny & Bougher (2017) are later homonyms and thus illegitimate per ICN Art. 53.1. As a result, the replacement names *I. austrofibrillosipes* and *I. fulvotomentosa* are introduced to replace the two illegitimate Australian names.

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New records of *Haematomma* and *Ophioparma* from China

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Abstract—*Haematomma caperaticum* and *Ophioparma rubricosa* are newly reported from China, and *H. africanum* and *H. wattii* are reported for the first time from mainland China.

Key words—East Asia, *Haematommataceae,* lichenized fungi, *Ophioparmaceae,* taxonomy

Introduction

Haematomma A. Massal. was described by Massalongo in 1852. It is usually recognized by lecanorine apothecia with a bright red to orange-red epihymenium; *Lecanora*-type or *Haematomma*-type asci; colourless, fusiform to broadly acicular, transversely multiseptate ascospores; and the presence of atranorin (Brodo & al. 2008, Nelsen & al. 2006, Nash & al. 2004, Smith & al. 2009). This genus is common in the world's temperate and tropical regions (McCarthy & Mallett 2004). *Ophioparma* Norman resembles *Haematomma* in its red to orange-red discs but differs in its secondary chemistry—*Haematomma* produces haematommone or russulone, (K+ purple or K+ red) while *Ophioparma* produces haemoventosin (K+ blue) (Smith & al. 2009).

Molecular analyses have clearly supported placement of *Ophioparma* in *Ophioparmaceae* (Wedin & al. 2005). However, the position of *Haematomma* is still debated, with some authors placing it in *Lecanoraceae*, others in *Haematommataceae* (Brodo & al. 2008, McCarthy & Mallett 2004); the use of molecular methods by Kalb & al. (2008) and Lumbsch & al. (2008) have thus far failed to resolve this problem.

Here we describe Chinese material representing four species of *Haematomma* and *Ophioparma*, two new to China and the other two new to mainland China.

Materials & methods

The studied specimens are housed in the Lichen Section of the Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). Their morphological characters were examined under an Olympus SZ51 stereomicroscope and an Olympus CX21 polarizing microscope. Both thallus and medulla were identified by testing with K (a 10% aqueous solution of potassium hydroxide) and C (a saturated solution of aqueous sodium hypochlorite). The lichen substances were identified using standardized thin layer chromatography techniques (TLC) with system C (Orange & al. 2010). The lichens were photographed using the SZX16 and BX61 microscopes attached to an Olympus DP72 digital camera.

Taxonomic descriptions

Haematomma africanum (J. Steiner) C.W. Dodge,
Beih. Nova Hedwigia 38: 39 (1971) Fig. 1a–e

Corticolous. Thallus crustose, continuous, rugose or rimose, roughened, without isidia or soredia, dull yellowish white, medulla I–; prothallus usually present. Apothecia rounded, deep reddish, sessile or constricted at base, dispersed, smooth, (0.5–)0.8–1.4 mm diam., margin distinct, crenulate or flexuose, usually prominent with disc; epihymenium red to orange-red, K+ purple, dissipating; hymenium hyaline, 50–75 μm tall; hypothecium hyaline, K–; paraphyses branched and anastomosing. Asci clavate, 8-spored; ascospores persistently colorless, strongly twisted in ascus, multi-septate, fusiform, curved, 21–24-celled in optical view, locules sometimes not equal in size, 50–75 × 5–7.5 μm. Pycnidia: not observed.

Chemistry—Cortex and medulla K+ yellow, C–, KC–. Atranorin, placodiolic acid, and haematommone detected by TLC.

Specimens examined: **China. Fujian, Wuyishan**, Tongmucun, alt. 1200 m, on bark, 26 Oct. 2010, X.R. Kou 20104860, 20104861 (SDNU). **Guizhou, Kaili**, Mt. Leigong, alt. 1800 m, on bark, 2 Apr. 2011, Y.L. Cheng 20112194 (SDNU).

Distribution—Central and South America, southern Africa, Australia, China (Taiwan), Costa Rica, India, Hawaii, Malaya, Japan, Philippines, and Papua New Guinea (Staiger & Kalb 1995, Aptroot & Sparrius 2003, Nelsen & al. 2006, Brodo & al. 2008). New to mainland China.

Comments—The Chinese material has ascospores with slightly more septa than previously cited for *H. africanum* (10–20-celled; Staiger& al. 1995) but otherwise agrees in morphology and chemistry.

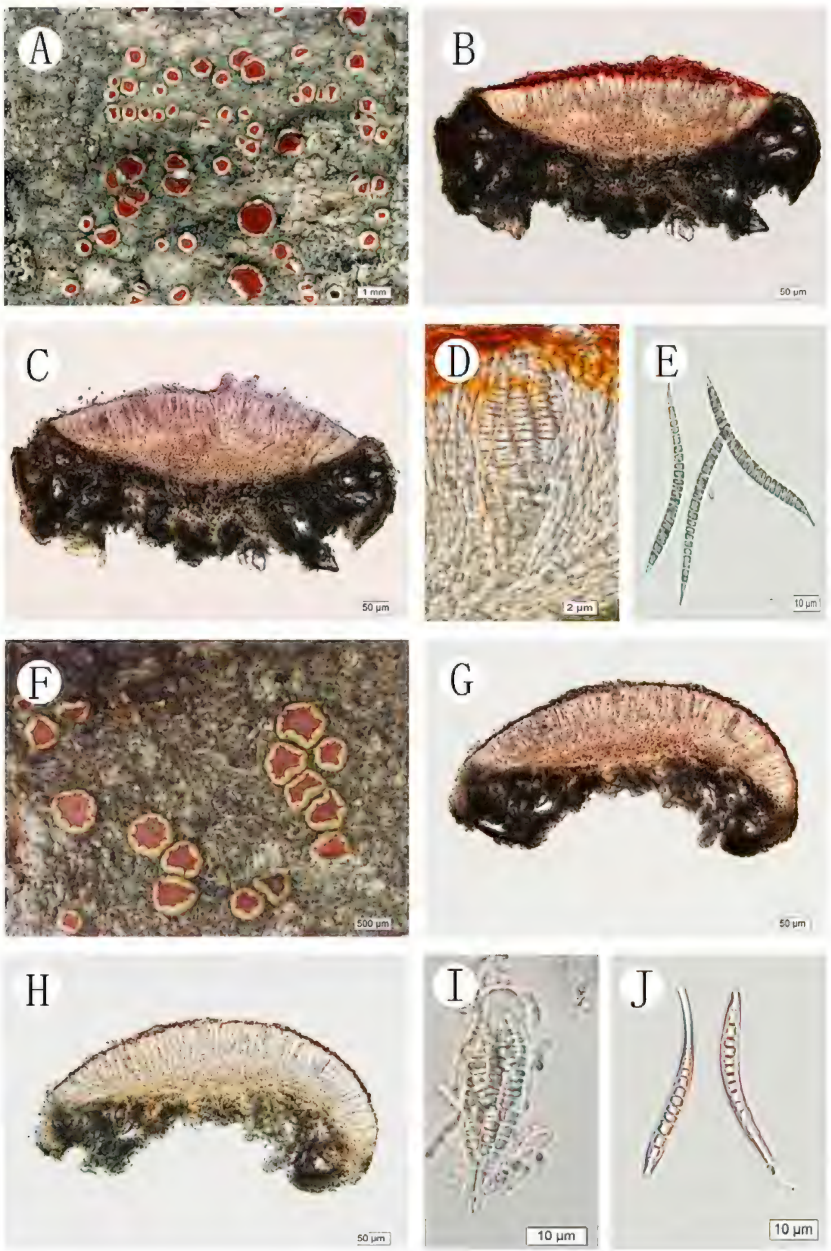

Fig. 1. ***Haematomma africanum***. A. Thallus; B. Apothecium section; C. K reaction; D. Ascus; E. Ascospores. ***Haematomma caperaticum***. F. Thallus; G. Apothecium section; H. K reaction; I. Ascus; J. Ascospores.

Haematomma africanum morphologically resembles *H. accolens* (Stirt.) Hillmann and they share a common chemistry, but *H. accolens* has smaller (42–62 × 3–5 µm) spores with fewer (6–8) cells (Brodo & al. 2008). Additionally, *H. accolens* usually has a thinner, more regular, apothecial margin.

Haematomma caperaticum Brodo, W.L. Culb. & C.F. Culb., Bryologist 111(3): 388 (2008) Fig. 1f–j

Corticolous. Thallus crustose, continuous, rugose or rimose, roughened, without isidia or soredia, dull yellowish white; prothallus not observed. Apothecia rounded, deep reddish, sessile or constricted at base, dispersed, smooth, yellowish pruinose, 0.5–0.8 mm diam., margin distinct, inward flexuose, usually prominent with disk; epihymenium red to orange–red, K+ purple, dissipating; hymenium hyaline, 50–62.5 µm tall; hypothecium hyaline or pale yellowish, K–; paraphyses branched and anastomosing, 2–2.5 µm diam. Asci clavate, 8-spored; ascospores persistently colorless, multi-septate, fusiform, curved, 8–15-celled in optical view, locules sometimes not equal in size, 62.5–75(–77.5) × 3–5 µm. Pycnidia: not observed.

Chemistry—Cortex and medulla K+ yellow, C–, KC–. Atranorin, placodiolic acid (minor), haematommone (minor), and caperatic acid detected by TLC.

Specimen examined: **China. Guangdong, Xinyi**, Dari Top, alt. 1700 m, on bark, 5 Nov. 2010, H.Y. Wang 20107544 (SDNU).

Distribution—Haiti, Dominican Republic, Jamaica. and Guatemala (Brodo & al. 2008). New to China.

Comments—The Chinese material closely matches the protologue description of *H. caperaticum* (Brodo & al. 2008). The most diagnostic characteristics of *Haematomma caperaticum* are the yellowish pruinose apothecia and the presence of caperatic acid.

Haematomma wattii (Stirt.) Zahlbr., Cat. Lich. Univers. 5: 776 (1928) Fig. 2a–e

Corticolous. Thallus crustose, continuous, rugose or rimose, roughened, without isidia or soredia, dull yellowish white or pale grey; prothallus usually present. Apothecia rounded, deep reddish, sessile or constricted at base, dispersed, smooth, epruinose, (0.3–)0.8–1.8 mm diam., margin distinct, crenulate or flexuose, usually prominent with disk; epihymenium red to orange-red, K+ purple, dissipating; hymenium hyaline, 75–90 µm tall; hypothecium hyaline or pale yellowish. Asci clavate, 4-spored; ascospores persistently colorless, muriform, fusiform, curved, 18–23-celled in optical

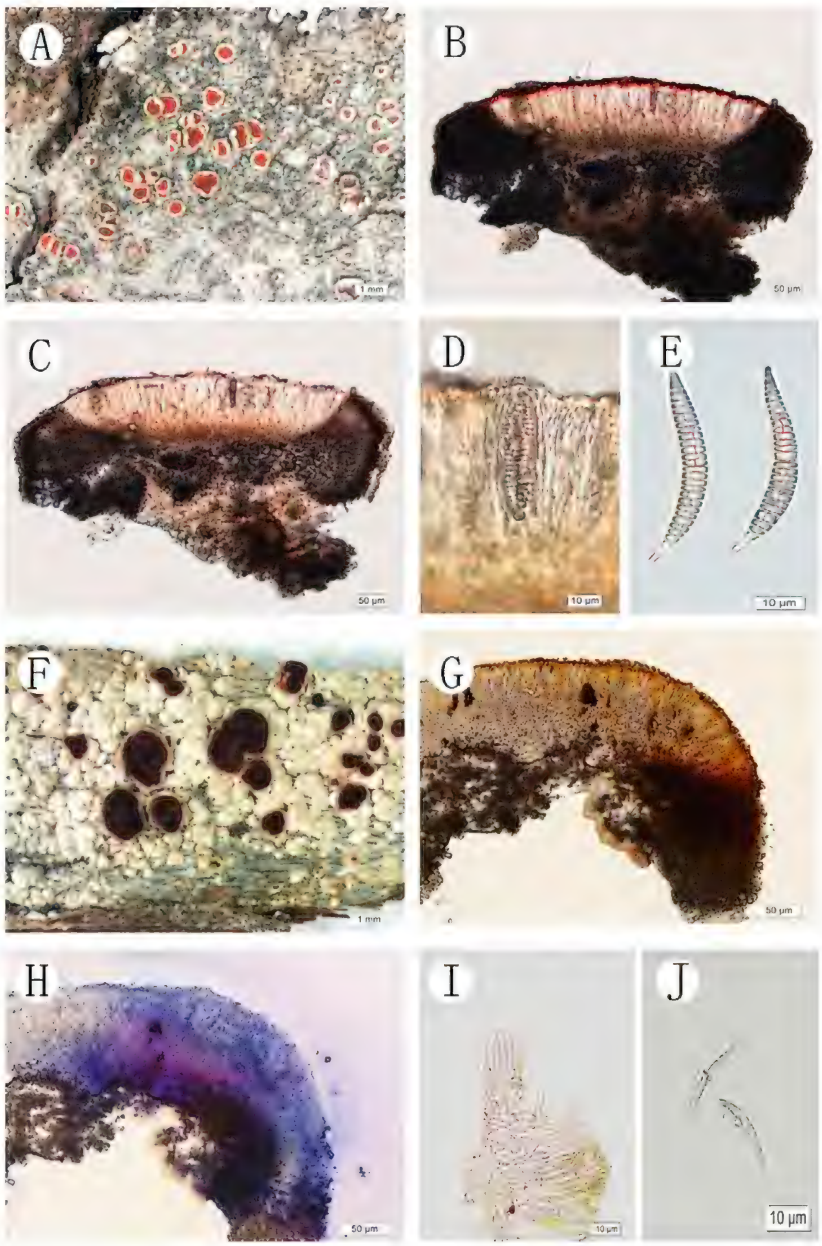

Fig. 2. ***Haematomma wattii***. A. Thallus; B. Apothecium section; C. K reaction; D. Ascus; E. Ascospores. ***Ophioparma rubricosa***. F. Thallus; G. Apothecium section; H. K reaction; I. Ascus; J. Ascospores.

view, locules sometimes not equal in size, 62.5–82.5(–100) × 6.25–7.5(–10) µm. Pycnidia: not observed.

Chemistry—Cortex and medulla K+ yellow, C–, KC–. Atranorin, placodiolic acid, and haematommone detected by TLC.

Specimens examined: **CHINA. Guizhou, Kaili**, Mt. Leigong, alt. 1800 m, on bark, 24 Aug. 2010, Z.L. Huang 20103177, 20103190 (SDNU); 2 Apr. 2011, Y.L. Cheng 20112441, 20112674 (SDNU). **Jiangxi, Ji'an**, Qianmocun, alt. 1300 m, on bark, 1 Nov. 2010, H.Y. Wang 20106037 (SDNU).

Distribution—China (Taiwan), India, Thailand, Borneo, Malaysia, Philippines, and Papua New Guinea (Aptroot & Sparrius 2003, Brodo & al. 2008). New to mainland China.

Comments—The Chinese material closely matches previously published descriptions of *H. wattii* (McCarthy & Mallett 2004). *Haematomma wattii* is chemically similar to *H. africanum*, which differs by its muriform and thicker ascospores (see Comments, above, under *Haematomma africanum*).

Ophioparma rubricosa (Müll. Arg.) S. Ekman,
Opera Bot. 127: 133 (1996) Fig. 2f–j

Corticolous. Thallus granular, without isidia or soredia, pale yellowish white; prothallus not observed. Apothecia red, dispersed, smooth, epruinose, 0.5–1.5 mm diam., margin thin and disappears in old apothecia; epihymenium orange-red, K+ blue; hymenium hyaline, 60–65 µm tall; hypothecium hyaline. Asci clavate, 8-spored; ascospores persistently colorless, multiseptate, fusiform, 3–4-celled in optical view, 30–42.5 × 2.5–3 µm. Pycnidia: not observed.

Chemistry—Thallus K–, C–, KC–. Divaricatic acid, haemoventosin, usnic acid (minor), and nordivaricatic acid (minor) detected by TLC.

Specimen examined: **CHINA. Xizang, Linzhi**, Lulang, Mt. Sejila, alt. 4400 m, on bark, 27 Oct. 2007, G.Y. Han 20073332 (SDNU).

Distribution—U.S.A. and Canada (Martínez & Aragón 2003, Brodo & al. 2001). New to China.

Comments—The Chinese material closely matches previously published descriptions of *O. rubricosa* (Brodo & al. 2001). The most diagnostic character of *Ophioparma rubricosa* is its granular thallus. It is morphologically similar to *Ophioparma araucariae* (Follmann) Kalb & Staiger, which differs by containing thamnolic acid.

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Chinese black truffles: *Tuber yigongense* sp. nov., taxonomic reassessment of *T. indicum* s.l., and re-examination of the *T. sinense* isotype

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Abstract—A new species, *Tuber yigongense,* is described. ITS sequences derived from Chinese black truffles grouped into three clusters, each recognised as a different species: *T. sinense*, *T. formosanum*, and *T. yigongense*. *Tuber sinense* and *T. formosanum* cannot be separated morphologically, but *T. yigongense* differs from them by its yellow brown ascospores. Based on ITS sequence analysis, numerous Chinese specimens previously identified as *T. indicum* and *T. himalayense* are redetermined as either *T. sinense* or *T. formosanum*; although the phylogenetic results suggest that the two Indian species do not occur in China, the true taxonomic affinities cannot be fully resolved because of the lack of Indian sequences of *T. indicum* and *T. himalayense.*

Key words—*Ascomycetes,* biogeography, DNA sequence, taxonomy, *Tuberaceae*

Introduction

Although Chinese truffles have been finding their way onto restaurant tables around the world over the past two decades, there is still confusion as to which taxonomic names should be applied. *Tuber indicum* Cooke & Massee was described from Mussooree [Mussoorie], near Dehradun in

northwest India (Cooke & Massee 1892), and a second Indian species, based on a specimen from the same locality, was described as *Tuber himalayense* B.C. Zhang & Minter (Zhang & Minter 1988). In 1988 some specimens from Sichuan province were sent to Shanxi University and described as a new species *Tuber sinense* K. Tao & B. Liu based on morphological features (Tao & al. 1989). Prof. M. Zang identified a similar collection from Yunnan province as *T. indicum* (Zang 1992). Prof. Zang's opinion was widely accepted in China, and *T. sinense* was regarded as a synonym of the Indian species (Comandini & Pacioni 1997, Zhuang 1998, Riousset & al. 2001, Zhang & al. 2005, Song 2005, Chen 2007, Hall & al. 2007, Kinoshita & al. 2011, Bonito & al. 2013, Li & al. 2015, Zambonelli & al. 1997). Dr. H.T. Hu, who also found black truffles on Taiwan Island about the same time, proposed to name these "*Tuber formosanum*" H.T. Hu (Hu 1992), but this name was invalid as no type was assigned. It was later validly re-described as *T. formosanum* H.T. Hu & Y. Wang (Qiao & al. 2013). Because of its morphological similarity to the other Chinese black truffles, *T. formosanum* has also been treated as a synonym of *T. indicum* by some authors (Song 2005, Chen 2007, Cao 2010).

Molecular phylogenetic analyses have revealed that there are at least two distinct lineages in Chinese black truffles, strongly suggesting that there are two species. The two lineages have been interpreted in four different ways: (1) as "*Tuber indicum*-A" and "*Tuber indicum*-B" (Kinoshita & al. 2011, Bonito & al. 2013, Belfiori & al. 2013); (2) as two geographical ecotypes (Wang & al. 2006, Chen & al. 2016); (3) as two cryptic species (Chen & al. 2011, 2016); or (4) as *T. indicum* and *T. himalayense* (Zhang & al. 2005, Feng & al. 2016).

In this study, phylogenetic analyses were conducted on the Chinese black truffles using the ITS-nrDNA sequence, the popularly accepted DNA marker for species delimitation in *Tuber* (Bonito & al. 2010, 2013; Kinoshita & al. 2011; Fan & al. 2016a,b), in order to clarify the species composition of the Chinese black truffles and apply the correct scientific names. The analyses also revealed a new species and some morphological differences between *T. indicum* and Chinese taxa.

Materials & methods

Morphological studies

Fresh truffles were collected from under *Pinus* spp. or *Castanea* spp. in mixed woodlands in Hebei, Yunnan, Sichuan, and Tibet, China. Specimens were preserved in the Herbarium, Biology Department, Capital Normal University, Beijing, China

Table 1. Newly generated ITS gene sequences from specimens representing *Tuber* species sampled in the phylogenetic study.

Taxon	Voucher	Origin	GenBank No.
T. formosanum	BJTC FAN107	Yunnan, China	MF621549
	BJTC FAN214	Yunnan, China	MF627984
	BJTC FAN329	Sichuan, China	MF627985
	BJTC FAN356	Sichuan, China	MF627986
	BJTC FAN363	Yunnan, China	MF627987
	BJTCFAN720	Hebei, China	MF627988
	BJTC FAN734	Hebei, China	MF627989
	BJTC FAN735	Hebei, China	MF627990
	BJTC FAN736	Hebei, China	MF627991
	BJTC FAN737	Hebei, China	MF627992
	BJTC FAN738	Hebei, China	MF627993
	BJTC FAN739	Hebei, China	MF627994
	BJTC FAN740	Hebei, China	MF627995
	BJTC FAN741	Hebei, China	MF627996
	BJTC FAN742	Hebei, China	MF627997
	BJTC FAN743	Hebei, China	MF627998
	BJTC FAN744	Hebei, China	MF627999
	BJTC FAN745	Hebei, China	MF628000
	BJTC FAN746	Hebei, China	MF628001
	BJTC FAN747	Hebei, China	MF628002
	BJTC FAN748	Hebei, China	MF628003
	BJTC FAN749	Hebei, China	MF628004
	BJTC FAN750	Hebei, China	MF628005
	BJTC FAN751	Hebei, China	MF628006
	BJTC FAN752	Hebei, China	MF628007
	BJTC FAN753	Hebei, China	MF628008
T. pseudohimalayaense	BJTC FAN122	Sichuan, China	MF627983
T. sinense	BJTC FAN108	Yunnan, China	MF627968
	BJTC FAN109	Yunnan, China	MF627969
	BJTC FAN110	Yunnan, China	MF627970
	BJTC FAN111	Yunnan, China	MF627971

Table 1 concluded on next page

Table 1, concluded

Taxon	Voucher	Origin	GenBank No.
	BJTC FAN112	Yunnan, China	MF627972
	BJTC FAN114	Yunnan, China	MF627973
	BJTC FAN115	Sichuan, China	MF627974
	BJTC FAN116	Sichuan, China	MF627975
	BJTC FAN117	Yunnan, China	MF627976
	BJTC FAN118	Yunnan, China	MF627977
	BJTC FAN119	Yunnan, China	MF627978
	BJTC FAN159	Yunnan, China	MF627979
	BJTC FAN261	Yunnan, China	MF627980
	BJTC FAN488	Yunnan, China	MF627981
	HMAS 60222 [**IT**]	Sichuan, China	MF627982
T. yigongense	BJTC FAN728	Tibet, China	MF663717
	BJTC FAN729	Tibet, China	MF663716
	BJTC FAN730	Tibet, China	MF663715
	BJTC FAN731 [**T**]	Tibet, China	MF663714

[T] = holotype: [IT] = isotype

(BJTC). Fresh specimens were evaluated macroscopically, and microscopic characters were described from both fresh and rehydrated specimens. Microscopic characteristics were observed from 10–20 µm thick hand-cut sections of dried specimens soaked in 5% KOH (w/v), Melzer's reagent and cotton blue in lactic acid. For scanning electron microscopy (SEM), spores were scraped from dried gleba, placed onto double-sided tape mounted directly on SEM stubs, coated with a 8-nm thick platinum-palladium film using a Hitachi E-1010 ion-sputter coater, and examined and photographed with a Hitachi S-4800 scanning electron microscope.

DNA extraction, PCR amplification, and sequencing

Herbarium specimens were crushed by shaking for 30 s at 30 Hz, 2–4 times using a Mixer Mill MM 301 in a 1.5 ml tube together with one 3 mm diam. tungsten carbide ball, and total genomic DNA was extracted using CTAB. The internal transcribed spacer (ITS) region of nuclear ribosomal DNA (nrDNA) was amplified using primers ITS1f/ITS4 (White & al. 1990, Gardes & Bruns 1993). DNA was amplified in 50 µl reactions containing DNA template 2 µl primer (10 µM) 2 µl each, 2× Master Mix 25 µl as follows: an initial denaturation at 94°C for 3 min, followed by 35 cycles at 94°C for 30 s, 50°C for 45 s, 72°C for 1 min, and a final extension at 72°C for 10 min. The PCR products were purified, sequenced, and edited by Beijing Zhongkexilin Biotechnology Co. Validated sequences are stored in the NCBI database

(http://www.ncbi.nlm.nih.gov/) under the accession numbers listed in Table 1. Additional ITS sequences (Fig. 1), including all available sequences from Chinese black truffles, were downloaded from the NCBI database.

Phylogenetic analysis

An ITS-nrDNA dataset was compiled to identify and investigate the phylogenetic placement of the black truffle species. Sequences alignments for each locus were performed in webPRANK (Löytynoya & Goldman 2005, using the -F setting) under default parameters and manually edited at misaligned sites. Poorly aligned sites for final sequence alignments were identified and ambiguous sites were excluded by Gblocks v. 0.91b (Castresana 2000; using default options except "Allowed Gap Positions" = half) with default parameters.

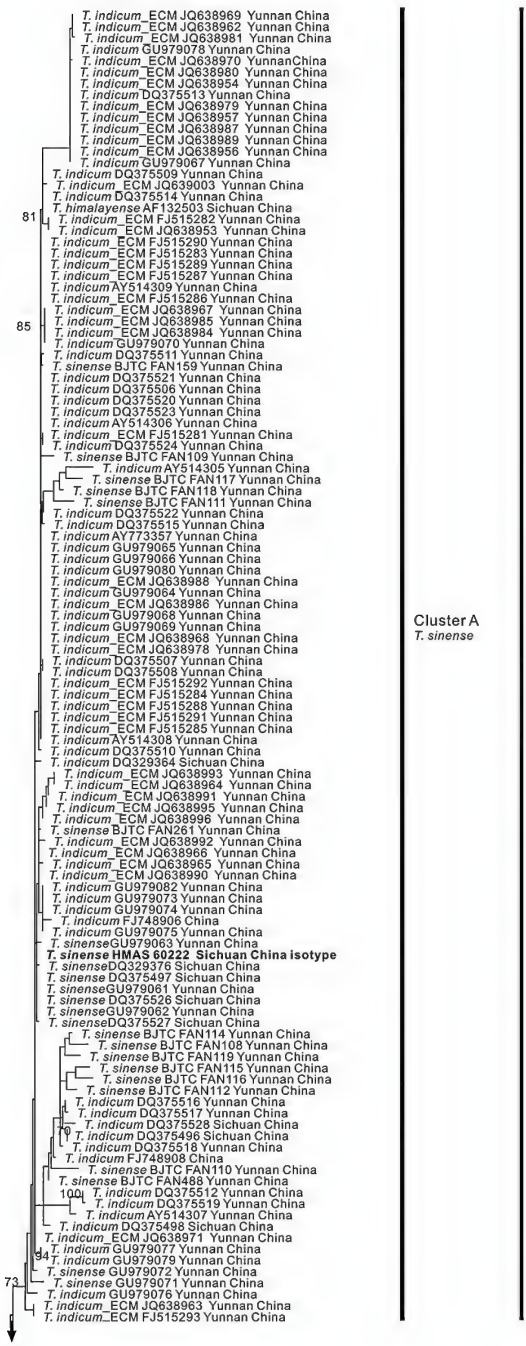
Maximum likelihood (ML) analysis was conducted using RAxML 8.0.14 (Stamatakis & al. 2005; Stamatakis 2006, 2014) and the GTRGAMMAI substitution model with parameters unlinked. ML bootstrap replicates (1000) were computed in RAxML using a rapid bootstrap analysis and search for the best-scoring ML tree. The ML trees were viewed with TreeView32 (Page 2001). Clades with a bootstrap support (BS) ≥70% were considered significantly supported (Hillis & Bull 1993).

Phylogeny

The ITS nrDNA alignment of 224 sequences comprised 575 characters; of the 370 variable sites, 60.18% (343) sites were informative. The resulting best ML tree (Fig. 1) grouped all sequences cited here (including two from European black truffle, others from Japanese black truffle, and all available GenBank ITS sequences derived from Chinese black truffles) into five clusters with strong support (BS ≥73%). The five clusters corresponded to European *T. melanosporum* Vittad., Japanese *Tuber* sp. 7 (Kinoshita & al. 2011), and three Chinese clusters designated as Clusters A–C (Fig. 1).

Cluster A contained our 15 newly generated *T. sinense* sequences (including the isotype sequence; Table 1) and 99 Chinese sequences [previously deposited as "*T. indicum*" (91), "*T. himalayense*" (1), or "*T. sinense*" (7)] (Fig. 1). Sequence similarity analysis showed that Cluster A sequences shared >98% ITS sequence identity and <94% similarity with other *Tuber* sequences.

Cluster B contained our 26 newly generated *T. formosanum* sequences (Table 1) and 55 Chinese sequences [previously deposited as "*T. indicum*" (49), "*T. himalayense*" (1), "*T. formosanum*" (3, including the holotype), or "*Tuber* sp." (2)] and two Japanese sequences [previously deposited as "*Tuber* sp. 6"] (Fig. 1). Cluster B sequences shared >98% ITS sequence identity and >94% similarity with other *Tuber* sequences.


T. indicum_ECM JQ638969 Yunnan China
T. indicum_ECM JQ638962 Yunnan China
T. indicum_ECM JQ638981 Yunnan China
T. indicum GU979078 Yunnan China
T. indicum_ECM JQ638970 YunnanChina
T. indicum_ECM JQ638980 Yunnan China
T. indicum_ECM JQ638954 Yunnan China
T. indicum DQ375513 Yunnan China
T. indicum_ECM JQ638979 Yunnan China
T. indicum_ECM JQ638957 Yunnan China
T. indicum_ECM JQ638987 Yunnan China
T. indicum_ECM JQ638989 Yunnan China
T. indicum_ECM JQ638956 Yunnan China
T. indicum GU979067 Yunnan China
T. indicum DQ375509 Yunnan China
T. indicum_ECM JQ639003 Yunnan China
T. indicum DQ375514 Yunnan China
T. himalayense AF132503 Sichuan China
81
T. indicum_ECM FJ515282 Yunnan China
T. indicum_ECM JQ638953 Yunnan China
T. indicum_ECM FJ515290 Yunnan China
T. indicum_ECM FJ515283 Yunnan China
T. indicum_ECM FJ515289 Yunnan China
T. indicum_ECM FJ515287 Yunnan China
T. indicum AY514309 Yunnan China
T. indicum_ECM FJ515286 Yunnan China
T. indicum_ECM JQ638967 Yunnan China
T. indicum_ECM JQ638985 Yunnan China
85
T. indicum_ECM JQ638984 Yunnan China
T. indicum GU979070 Yunnan China
T. indicum DQ375511 Yunnan China
T. sinense BJTC FAN159 Yunnan China
T. indicum DQ375521 Yunnan China
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T. indicum DQ375523 Yunnan China
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T. indicum GU979074 Yunnan China
T. indicum FJ748906 China
T. indicum GU979075 Yunnan China
T. sinense GU979063 Yunnan China
T. sinense HMAS 60222 Sichuan China isotype
T. sinense DQ329376 Sichuan China
T. sinense DQ375497 Sichuan China
T. sinense GU979061 Yunnan China
T. sinense DQ375526 Sichuan China
T. sinense GU979062 Yunnan China
T. sinense DQ375527 Sichuan China
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T. sinense BJTC FAN119 Yunnan China
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T. sinense BJTC FAN116 Yunnan China
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T. indicum DQ375516 Yunnan China
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T. indicum DQ375528 Sichuan China
70
T. indicum DQ375496 Sichuan China
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T. sinense BJTC FAN488 Yunnan China
100
T. indicum DQ375512 Yunnan China
T. indicum DQ375519 Yunnan China
T. indicum AY514307 Yunnan China
T. indicum DQ375498 Sichuan China
T. indicum_ECM JQ638971 Yunnan China
94
T. indicum GU979077 Yunnan China
T. indicum GU979079 Yunnan China
T. sinense GU979072 Yunnan China
73
T. sinense GU979071 Yunnan China
T. indicum GU979076 Yunnan China
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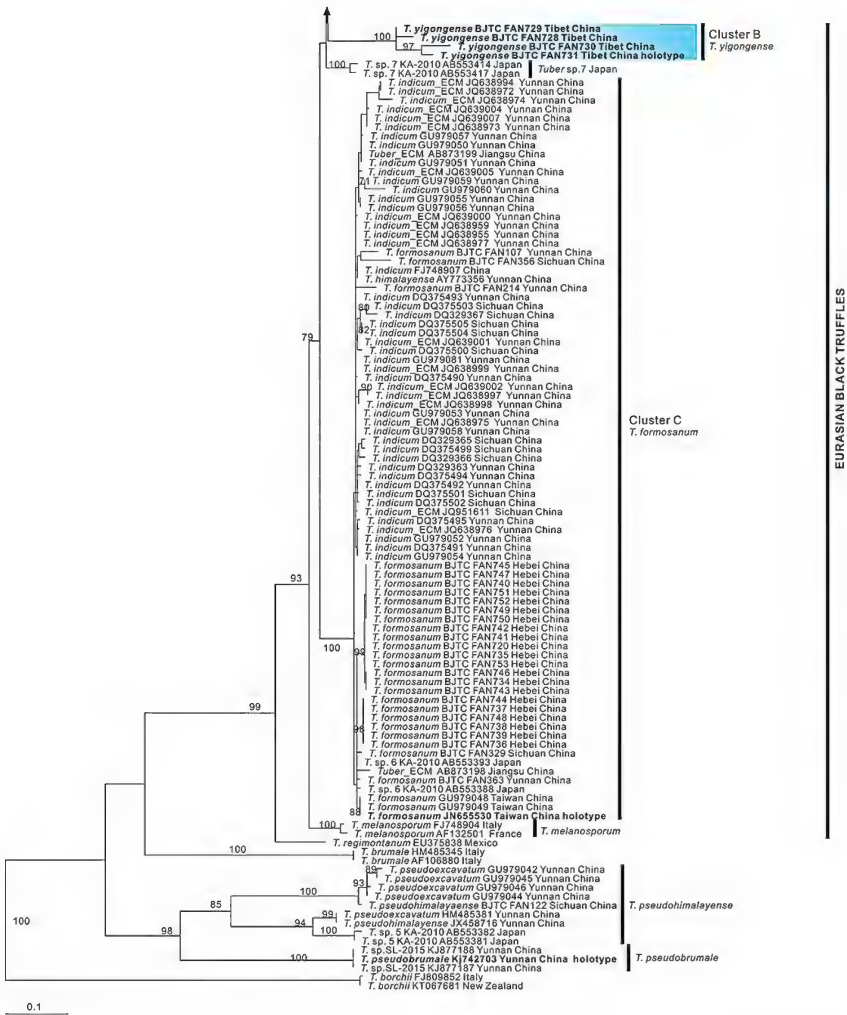
T. indicum_ECM FJ515293 Yunnan China
Cluster A
T. sinense
EURASIAN BLACK TRUFFLES


T. yigongense BJTC FAN729 Tibet China
T. yigongense BJTC FAN728 Tibet China
T. yigongense BJTC FAN739 Tibet China
T. yigongense BJTC FAN731 Tibet China holotype
Cluster B
T. yigongense
T. sp. 7 KA-2010 AB553414 Japan
T. sp. 7 KA-2010 AB553417 Japan
Tuber sp.7 Japan
T. indicum_ECM JQ638994 Yunnan China
T. indicum_ECM JQ638972 Yunnan China
T. indicum_ECM JQ638974 Yunnan China
T. indicum_ECM JQ639004 Yunnan China
T. indicum_ECM JQ639007 Yunnan China
T. indicum_ECM JQ638973 Yunnan China
T. indicum GU979057 Yunnan China
T. indicum GU979050 Yunnan China
Tuber_ECM AB873199 Jiangsu China
T. indicum GU979051 Yunnan China
T. indicum_ECM JQ639005 Yunnan China
T. indicum GU979059 Yunnan China
T. indicum GU979060 Yunnan China
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T. indicum_ECM JQ638955 Yunnan China
T. indicum_ECM JQ638977 Yunnan China
T. formosanum BJTC FAN107 Yunnan China
T. formosanum BJTC FAN356 Sichuan China
T. indicum FJ748907 China
T. himalayense AY773359 Yunnan China
T. formosanum BJTC FAN214 Yunnan China
T. indicum DQ375493 Yunnan China
T. indicum DQ375503 Sichuan China
T. indicum DQ329367 Sichuan China
T. indicum DQ375505 Sichuan China
T. indicum DQ375504 Sichuan China
T. indicum_ECM JQ639001 Yunnan China
T. indicum DQ375500 Sichuan China
T. indicum GU979081 Yunnan China
T. indicum_ECM JQ638999 Yunnan China
T. indicum DQ375490 Yunnan China
T. indicum_ECM JQ639002 Yunnan China
T. indicum_ECM JQ638997 Yunnan China
T. indicum_ECM JQ638998 Yunnan China
T. indicum GU979053 Yunnan China
T. indicum_ECM JQ638975 Yunnan China
T. indicum GU979058 Yunnan China
Cluster C
T. formosanum
T. indicum DQ329365 Sichuan China
T. indicum DQ375499 Sichuan China
T. indicum DQ329366 Sichuan China
T. indicum DQ329363 Yunnan China
T. indicum DQ375494 Yunnan China
T. indicum DQ375492 Yunnan China
T. indicum DQ375501 Sichuan China
T. indicum DQ375502 Sichuan China
T. indicum_ECM JQ951611 Sichuan China
T. indicum DQ375495 Yunnan China
T. indicum_ECM JQ638976 Yunnan China
T. indicum GU979052 Yunnan China
T. indicum DQ375491 Yunnan China
T. indicum GU979054 Yunnan China
T. formosanum BJTC FAN745 Hebei China
T. formosanum BJTC FAN747 Hebei China
T. formosanum BJTC FAN740 Hebei China
T. formosanum BJTC FAN751 Hebei China
T. formosanum BJTC FAN752 Hebei China
T. formosanum BJTC FAN749 Hebei China
T. formosanum BJTC FAN750 Hebei China
T. formosanum BJTC FAN742 Hebei China
T. formosanum BJTC FAN741 Hebei China
T. formosanum BJTC FAN720 Hebei China
T. formosanum BJTC FAN735 Hebei China
T. formosanum BJTC FAN753 Hebei China
T. formosanum BJTC FAN746 Hebei China
T. formosanum BJTC FAN734 Hebei China
T. formosanum BJTC FAN743 Hebei China
T. formosanum BJTC FAN744 Hebei China
T. formosanum BJTC FAN737 Hebei China
T. formosanum BJTC FAN748 Hebei China
T. formosanum BJTC FAN738 Hebei China
T. formosanum BJTC FAN739 Hebei China
T. formosanum BJTC FAN736 Hebei China
T. formosanum BJTC FAN329 Sichuan China
T. sp. 6 KA-2010 AB553393 Japan
Tuber_ECM AB873198 Jiangsu China
T. formosanum BJTC FAN363 Yunnan China
T. sp. 6 KA-2010 AB553388 Japan
T. formosanum GU979046 Taiwan China
T. formosanum GU979049 Taiwan China
T. formosanum JN655539 Taiwan China holotype
T. melanosporum FJ748904 Italy
T. melanosporum AF132501 France
T. melanosporum
T. regimontanum EU375838 Mexico
T. brumale HM485345 Italy
T. brumale AF106880 Italy
T. pseudoexcavatum GU979042 Yunnan China
T. pseudoexcavatum GU979045 Yunnan China
T. pseudoexcavatum GU979046 Yunnan China
T. pseudoexcavatum GU979044 Yunnan China
T. pseudohimalayense BJTC FAN122 Sichuan China
T. pseudohimalayense
T. pseudoexcavatum HM485381 Yunnan China
T. pseudohimalayense JX458716 Yunnan China
T. sp. 5 KA-2010 AB553382 Japan
T. sp. 5 KA-2010 AB553381 Japan
T. sp.SL-2015 KJ877188 Yunnan China
T. pseudobrumale KJ742703 Yunnan China holotype
T. pseudobrumale
T. sp.SL-2015 KJ877187 Yunnan China
T. borchii FJ809852 Italy
T. borchii KT067681 New Zealand
EURASIAN BLACK TRUFFLES
0.1

FIG. 1 (left+right). Phylogeny derived from maximum likelihood analysis of the ITS rDNA sequences of Eurasian black truffle species and related *Tuber* species, using *T. borchii* as outgroup. Bootstrap values >70% from 1000 replications are shown above the branches.

Cluster C, containing four sequences derived from our newly proposed *Tuber yigongense,* shared >99% ITS sequence identity and <93% similarity with other *Tuber* sequences.

Each of the three Clusters A–C represents a single species, according to the *Tuber* species delimitation criterion of 95% sequence identity suggested by Kinoshita & al. (2011).

Taxonomy

Tuber yigongense L. Fan & W.P. Xiong, **sp. nov.** Fig. 2a–d

Fungal Name FN570492

Differs from other *Tuber* species by its dark brown to blackish ascomata and its yellow brown ascospores with a densely spiny reticulatum.

Type—China, Tibet, Linzhi City, Bomi County, Yigong Town, Jiangsegang Village, 2230 m, in soil under *Pinus* sp., 15 Nov. 2016, Wei-Ping Xiong, Jun-Li Zhang & Hui-Juan Sun X00486 (**Holotype**, BJTC FAN731; GenBank MF663714).

Etymology—referring to the type locality.

Ascomata globose to subglobose, slightly lobed, firm, reddish brown when young, dark brown to blackish at maturity, 1.5–10 cm diam., with distinct pentagonal and pyramidal warts on the ascomatal surface, having 4–5 ridges ≤0.6 mm high. Odor aromatic at maturity. Peridium 250–550 µm thick (excluding 300–600 µm high warts), two-layered: outer layer 225–300 µm thick, pseudoparenchymatous, composed of angular or irregular cells of (7.5–)12.5–30(–37.5) × (5–)7.5–15(–20) µm diam., thin-walled, walls gradually becoming brown towards outer surface; inner layer 200–300 µm thick, composed of hyaline interwoven hyphae, 2.5–5 µm diam., thin-walled, septate. Gleba solid, whitish, light yellowish when young, gradually becoming brown to dark brown at maturity, marbled with numerous thin whitish meandering veins. Asci globose, subglobose, or broadly ellipsoid, 62.5–75 × 50–62.5 µm, sessile at maturity, hyaline, thin-walled, 1–5-spored, randomly dispersed in glebal tissue. Ascospores ellipsoid (usually a few broadly ellipsoid or subglobose), hyaline when young, yellow brown at maturity; excluding ornamentation 35–45 × 25–30 µm in 1-spored asci, 30–37.5 × 20–25 µm in 2-spored asci, and 20–32.5 × 17.5–22.5 µm in 3–5-spored asci, ornamented mostly by an irregular densely spiny reticulatum with occasional isolated spines, 2.5–4 µm tall, straight or strongly curved at apex.

Additional specimens examined—**China. Tibet, Linzhi City**, Bomi County, Yigong town, Jiangsegang village, 2230 m, in soil under *Pinus* sp., 26 July 2016, Wei-Ping Xiong, & Jun-Li Zhang X00454-1 (BJTC FAN728; GenBank MF663717), X00454-2 (BJTC FAN729; GenBank MF663716); 15 Nov. 2016, Wei-Ping Xiong, Jun-Li Zhang, & Hui-Juan Sun X00485 (BJTC FAN730; GenBank MF663715).

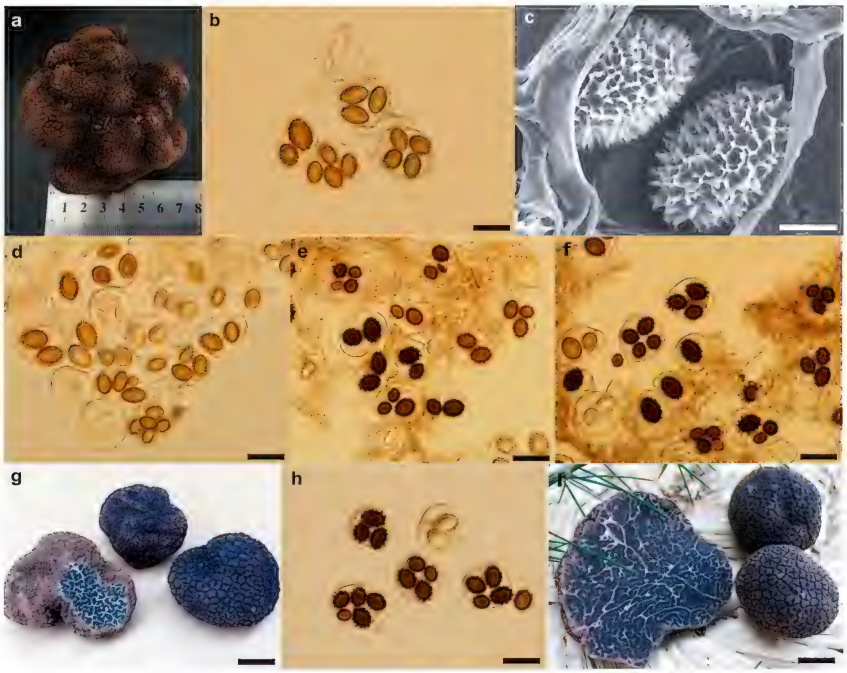

Fig. 2. Chinese *Tuber* species. ***Tuber yigongense*** (BJTC FAN731, holotype). a. Ascoma; b, d. Asci and ascospores (LM); c. Ascospores (SEM). ***Tuber formosanum*** (BJTC FAN720). e, f. Asci and ascospores (LM); g. Ascomata; ***Tuber sinense*** (BJTC FAN108). h. Asci and ascospores (LM); i. Ascomata. Scale Bars: a, g, i = 1 cm; b, d–f, h = 10 μm; c = 50 μm.

Comments—*Tuber yigongense* greatly resembles both *T. sinense* and *T. formosanum* in ascoma appearance as they all have large dark brown fruit-bodies covered by pyramidal warts. However, the yellow-brown ascospores of *T. yigongense* set it apart from *T. sinense* and *T. formosanum,* which have red-brown to blackish brown ascospores.

Although *T. yigongense* shares a <93% ITS sequence similarity with *T. sinense* and *T. formosanum* (Fig. 1), its sequences form a strongly supported (100% BS) monophyletic clade, supporting *T. yigongense* as a distinct species. Similarly, *Tuber indicum* and *T. himalayense* from India, *Tuber* sp. 7 from Japan, and *T. melanosporum* from Europe had similar ascomata to *T. yigongense* but differed by their black-brown or red-brown ascospores with spiny or sparsely spiny-reticulate ornamentations. Because there is no DNA data available from the two Indian *Tuber* species, their

phylogenetic affinities with *T. yigongense* are yet to be resolved. We expect that additional collections *Tuber yigongense* will be found further afield, as more surveys are made in the area around Yigong.

Tuber sinense K. Tao & B. Liu,
J. Shanxi Univ. (Nat. Sci. Ed.) 12(2): 215 (1989) FIG. 2h,i
?MISAPPLIED NAME: *Tuber indicum* sensu auct. sin.

Tuber sinense, corresponding to Cluster A in ML tree (FIG. 1), was proposed by Tao & Liu (Tao & al. 1989) based on specimens from Huidong County, Sichuan Province, China. While this species is morphologically very similar to *T. indicum*, there is no molecular evidence that can confirm *T. indicum* and *T. sinense* are conspecific; all DNA data under the name of *T. indicum* in public databases and academic papers are derived not from Indian collections, but from China. We believe that "*T. indicum*" has been misapplied to Chinese specimens with Cluster A sequences, and that *T. sinense* is the appropriate name for Chinese specimens collected within Southwestern China.

Tuber formosanum H.D. Hu & Y. Wang, Mycotaxon 123: 296 (2013) FIG. 2,e–g
?MISAPPLIED NAME: *Tuber indicum* sensu auct. sin.

Tuber formosanum, corresponding to Cluster B in our ML tree (FIG. 1), was initially proposed by Hu (1992) but not typified. Recently, Hu & Wang (Qiao & al. 2013) validated the name from Taiwan. *Tuber formosanum* is easily confused morphologically with *T. sinense*. Based on our observations, potential diagnostic distinctions between the two species include [1] the number of ascospores per ascus (1–6 in *T. sinense* vs. usually 1–4 in *T. formosanum*) and (2) ascospore ornamentation (mostly isolated spines in *T. sinense* vs. spines usually with many more basal connections in *T. formosanum*). Although *T. formosanum* was previously treated as a synonym of *T. indicum* (Chen 2007, Cao 2010), our phylogenetic analysis supports *T. formosanum* as a good species.

According to our study, *T. formosanum* has been recorded from Taiwan, Sichuan, Yunnan, Jiangsu, and Hebei provinces in China, and from Japan (as *Tuber* sp. 6; Kinoshita & al. 2011) (TABLE 1, FIG. 1).

Discussion

Species diversity and geography of Eurasian black truffles

Our ITS-based phylogenetic analysis (FIG. 1) of Asian and European black truffles supports the existence of at least 5 distinct phylogenetic

species: *Tuber melanosporum*, *T. formosanum*, *T. sinense*, *T. yigongense*, and *Tuber* sp. 7 (Japan). These species share many morphological features—large dark brown to blackish warty ascomata, a black gleba marbled with whitish vines, blackish or yellow brown (*T. yigongense*) ascospores ornamented with spines or a spine covered-reticulum—by which they are clearly separated from all other species in the genus. However, they are rather difficult to distinguish from one another using only morphological characters. One reason is that some important morphological features overlap among the species. For example, isolated spine ornamentation of spores is typical for *T. melanosporum*, but isolated spines (particularly on immature spores) are also often observed in *T. sinense;* similarly, spino-reticulate ascospore ornamentation, a diagnostic feature in *T. himalayense* (Zhang & Minter 1988), is also common and typical in both *T. yigongense* and *T. formosanum*. Secondly, some morphological characters often vary greatly within a species. For example, isolated ascospore spines predominate in some *T. sinense* specimens while the ornamentation is more spino-reticulate in others. Consequently, we think it is unworkable to identify black truffle species accurately without molecular data. *Tuber yigongense* might be an exception due to its generally pale yellow-brown ascospores, which make it easily distinguishable from other black truffle species.

Our molecular analysis suggests that *T. sinense* is limited to Southwestern China. *Tuber yigongense* has been found only in Tibet, and perhaps occurs in a region geographically isolated from the two other Chinese black truffles. In contrast, *T. formosanum* is widespread in Southwestern China (Yunnan and Sichuan provinces, where it overlaps with *T. sinense*), but it has also been collected from Taiwan (its type locality), Central China (Jiangsu province), Northern China (Hebei province), and Japan (Fig. 1). More recently, *T. formosanum* (as *Tuber indicum*-B, Bonito & al. 2011) was found fruiting in natural forest of North America, although its presence there might have been a deliberate introduction by human activity. However, a somewhat similar situation is observed in isolated pockets of *T. melanosporum* in southern Europe (Riousset & al. 2001, Hall & al. 2007) and *Tuber* sp. 7 (Japan) that appears native to Japan (Kinoshita & al. 2011). Thus, it seems probable that each known black truffle species is confined to a separate, relatively small area in the northern hemisphere.

Tuber indicum, T. himalayense, and Chinese black truffles

We exclude *T. indicum* and *Tuber himalayense* from the above discussion because the types (K39493, HMAS 68228) did not yield any useable DNA.

Their type locality is Mussoorie, near Dehradun in northern India on the southwestern Himalayan Plateau, which is separated from the type locality of *T. yigongense* by1600 km from Yigong on the northeastern part and the highest part of the Himalayan Plateau. This barrier and the distance between them and the other Asiatic species lead us to believe that *T. indicum* and *T. himalayense* might well be molecularly distinct from *T. yigongense* and the other species to the east.

Without supporting sequence data, it is unwise to assume that the Indian *T. indicum* and *T. himalayense* are conspecific with any of the Chinese black truffle species. For the time being, we think it is better to limit application of the names *T. indicum* and *T. himalayense* to Indian specimens, until authentic DNA material becomes available to resolve the taxonomic misunderstanding of the Chinese black truffles.

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Graphis maomingensis, a new lichenized fungus from China

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Abstract—*Graphis maomingensis* sp. nov. is described from Guangdong Province, eastern China. It is characterized by a concealed disc, striate labia, *striatula*-morph lirellae, completely carbonized proper exciple, and hyaline transversely 15-21-septate ascospores. The important characters of this species are illustrated. All materials are conserved in the Lichen Section of Botanical Herbarium, Shandong Normal University.

Key words—*Graphidaceae,* new species, *Ostropales,* taxonomy

Introduction

Graphis Adans. (*Graphidaceae*) belongs to *Ostropales*, which is the largest order within *Ostropomycetidae*, *Ascomycota* (Lumbsch & Huhndorf 2007, Kirk & al. 2008). The taxonomy of the genus (Staiger 2002) as revised by Lücking (2009) is characterized by sessile to immersed lirellae with well-developed labia, a carbonized excipulum, mostly non-inspersed hymenium, and hyaline, I+ violet-blue, distoseptate ascospores with lens-shaped lumina.

Worldwide, *Graphis* includes about 460 species (Feuerstein & al. 2016). In China, about 75 *Graphis* species have been recorded (Guo & Hur 2015, Joshi & al. 2015, Jia & Lücking 2017). During our study of the lichen flora of Mt. Datianding in Maoming, Guangdong Province, China, a new species of *Graphis* was found, described here as *G. maomingensis*.

[#] Lu-Lu Zhang & Meng-Zhu Yang contributed equally to this work.

Materials & methods

The specimens studied are conserved in the Lichen Section of Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). The materials were examined and measured using an Olympus SZ51 stereomicroscope, with the apothecial anatomy observed using an Olympus CX41 polarizing microscope. Morphological characters were photographed using Olympus SZX16 and BX61 (DP72) cameras. Spot colour tests and thin-layer chromatography (TLC, using solvent system C) followed standard lichen substance analysis protocols (Orange & al. 2010).

Taxonomy

Graphis maomingensis Meng Z. Yang & Lu L. Zhang, **sp. nov.** Pl. 1

MycoBank MB 824948

Differs from *Graphis bifera* by its *striatula*-morph lirellae and striate labia.

Type: China, Guangdong Province, Maoming City, Xinyi County, Mt. Datianding, 22°17′N 110°12′E, alt. 1700 m, on bark, 5.XI.2010, coll. Li Ming, 20106911 (**Holotype**, SDNU).

Etymology: The specific epithet '*maomingensis*' refers to Maoming, Guangdong Province, where the species was found.

Thallus corticolous, crustose, continuous, pallid to grey, smooth, tightly attached to the substratum, without isidia and soralia. Apothecia lirelliform, short to elongate, single, 0.5-5.5 × 0.2-0.4 mm, sessile, thalline margin basal or absent, scattered over the thallus, labia striate, non-pruinose; disc concealed, lirellae *striatula*-morph. Proper exciple conspicuous, completely carbonized, 33-139 µm thick; epithecium 14-27 µm high, brownish; hymenium clear, 139-163 µm high, I-; hypothecium brownish, 18-37 µm high. Paraphyses simple, 1-1.5 µm diam., apices unbranched; asci cylindrical to clavate, 2-4-spored; ascospores hyaline, ellipsoid, transversely septate, 16-22-locular, 54-87 × 6-10 µm, I+ violet, with a 5-7 µm thick halo.

Chemistry: K-, PD-, C-; no lichen compounds detected.

Additional specimens examined (all in SDNU): **China, Guangdong Province, Maoming City,** Xinyi County, Mt. Datianding, alt. 1700 m, 5.XI.2010, M. Li. 20106735, 20107687, 20106957, 20106890, 20107527A, 20107000, 20106954, 20106915, 20106889, 20106998, 20106955, 20106733, 20107455, 20107673, 20107654, 20107596; X.R. Kou 20107059; D.F. Jiang 20106683, 20107946A, 20107947A, 20107104, 20107815, 20106994, 20106683A, 20107946, 20107661, 20107059, 20107194; H.Y. Wang 20107520, 20107521, 20106612, 20107521A, 20107204, 20107221A, 20107256, 20107212, 20107518, 20107279, 20107553, 20107227, 20107064, 20107605, 20107552, 20107282, 20107549, 20106839, 20107548, 20107521B, 20106668, 20107582, 20107251, 20107217A, 20107064A, 20107598, 20107558, 20107276, 20107217, 20107520A.

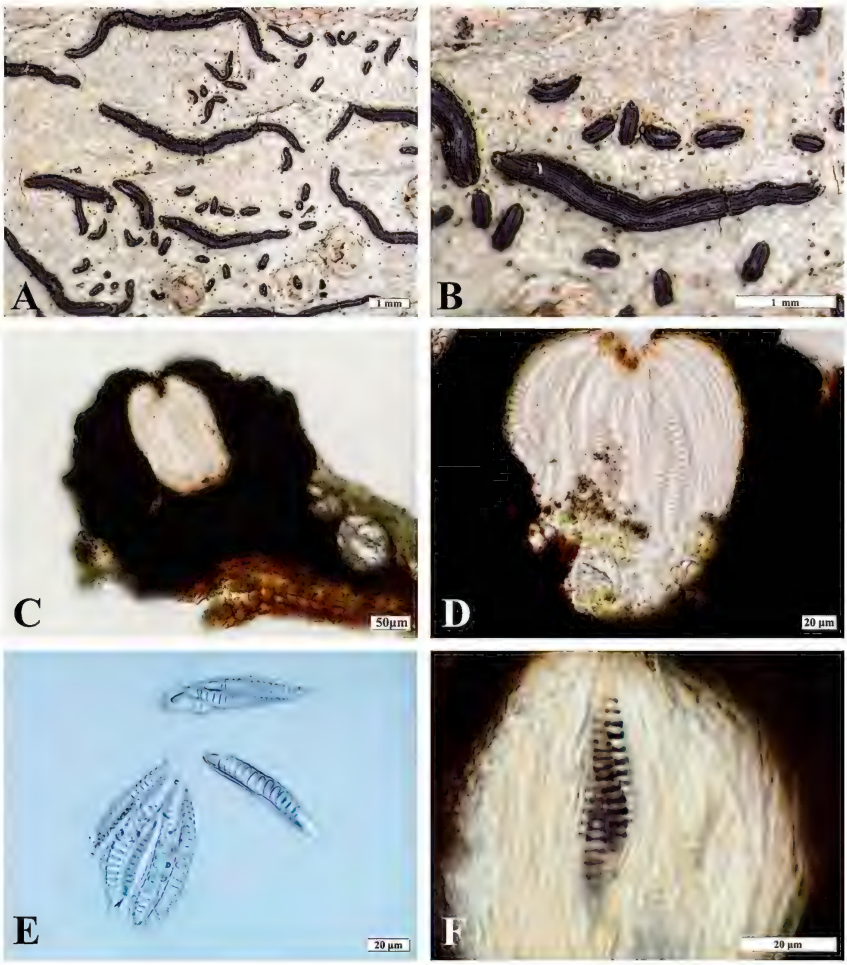

Plate 1. ***Graphis maomingensis*** (holotype). A, B. Thallus on bark; C, D. Section of apothecium; E. Ascospores; F. Ascospores I+ violet. Scale bars: A, B = 1 mm; C = 50 μm; D–F = 20 μm.

Ecology: *Graphis maomingensis* is known only from Datianding Mountain, Maoming City, Guangdong Province, growing on barks of various deciduous trees.

Comments: The new species is distinguished by its concealed disc, *striatula*-morph lirellae, completely carbonized proper exciple, and 2–4-spored asci. Other *Graphis* species differ from *G. maomingensis* by

6–8-spored asci (*G. contortuplicata;* Lücking & al. 2009), 8-spored asci (*G. striatula;* Archer 2006), *nuda*-morph (very short and unbranched) lirellae and entire labia (*G. bifera;* Lücking & al. 2009), or shorter (25–45 µm) ascospores (*G. duplicata;* Lücking & al. 2009).

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First record of *Morchella pulchella* from Pakistan

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Abstract—A species of true morel (*Morchella*) was collected in the Malam Jabba valley in the Swat District of Pakistan in April 2015. The specimen was identified by sequencing portions of RNA polymerase II largest subunit (RPB1), second largest subunit (RPB2), and translation elongation factor-1α (tef1). Phylogenetic analysis of the partial tef1 sequence indicated the collection was *M. pulchella*, previously reported from China, Turkey, and Europe. Our report extends its distribution range to Pakistan.

Key words—*Ascomycota*, edible fungi, *Morchellaceae*, phylogeny, systematics

Introduction

Malam Jabba is located in northern Pakistan between the Himalayan and Hindukush foothills in the Swat district of the Malakand Division in Khyber Pakhtunkhwa Province (KP). The area, with elevations ranging from 990 m at the valley entrance to 2880 m at the highest peak of Shagar Sar, is a mycologically rich region. In Pakistan, *Morchella* species fruit during spring at lower altitudes, but as late as July at higher elevations in snowfall regions (Hamayun & al. 2006, Badshah & al. 2015). True morels (*Morchella* spp.) belong to *Morchellaceae* Rchb. (*Pezizales*, *Ascomycota*) and are amongst the most highly valued edible fungi due to their excellent flavor and relatively short fruiting season (Taşkın & al. 2016). A high diversity of *Morchella* species has been described from various continents and regions, including Pakistan (Hamayun & al. 2006).

In recent years, a series of multilocus molecular phylogenetic studies of *Morchella* were performed employing phylogenetic species recognition based on genealogical concordance (GCPSR, sensu Taylor & al. 2000). These studies revealed considerable continental endemism and provincialism within the genus (O'Donnell & al. 2011; Du & al. 2012a,b; Richard & al. 2015; Loizides & al. 2016; Taşkın & al. 2010, 2012, 2016). This research also highlighted the difficulties surrounding morphology-based species identification and helped provide a robust framework for subsequent taxonomic revisions (Clowez 2012, 2014, 2015; Kuo & al. 2012; Richard & al. 2015; Voitk & al. 2016; Loizides & al. 2015, 2016). Multilocus molecular phylogenetic studies have so far revealed nearly 70 *Morchella* spp. worldwide (Loizides 2017).

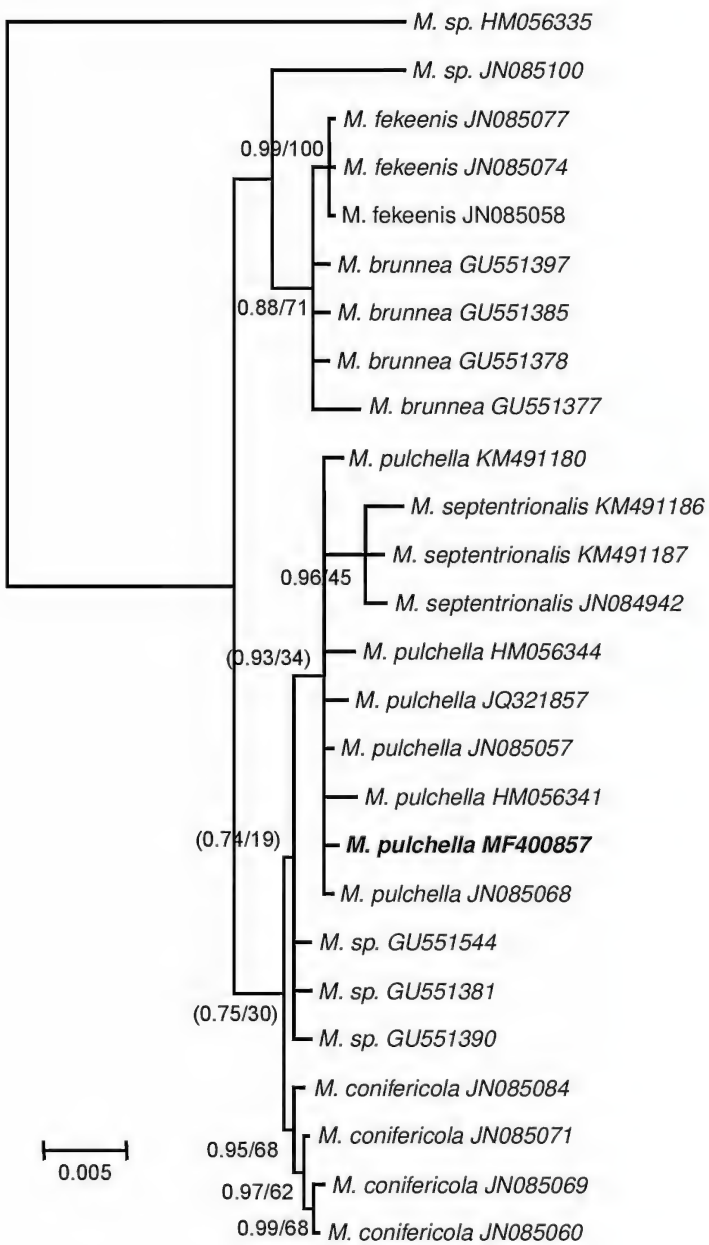
A number of morel species—*Morchella conica, M. crassipes, M. elata, M. esculenta, M. rotunda, M. semilibera*—have been previously reported from the Kohistan and Swat regions of Pakistan based solely on morphology (Hamayun & al. 2006). These identifications based on old taxonomical concepts have not, however, been verified by molecular analysis. In this paper we report *Morchella pulchella* as a new record from Pakistan identified primarily using DNA sequence analysis.

Materials & methods

Specimens were collected during a field survey at Malam Jabba, District Swat, Province Khyber Pakhtunkhwa, Pakistan, in April 2015 under *Pinus wallichiana* near grasses. Tissues were mounted in glycerin or distilled water and examined microscopically using a Leitz HM Lux compound microscope under 400× magnification. The preserved specimens have been deposited in the herbarium of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan (ISL).

DNA extraction and PCR amplification were conducted with the Sigma-Aldrich REDExtract-N-Amp™ Plant PCR Kit following the manufacturer's instructions. DNA was amplified with the following markers and primer pairs: translation elongation factor 1-α (TEF1) with EF526F & EF3AR (Rehner & Buckley 2005), RNA polymerase II large subunit (RPB1) with gRPB1A & aRPB1C (Matheny & al. 2002) and the RNA polymerase II second largest subunit (RPB2) with 9F & 3R (Liu & al. 1999). One µL of genomic DNA was amplified in total volumes of 20 µL in an Eppendorf Master Cycler Gradient thermocycler following the parameters of 94°C for 3 min, 35 cycles of 94°C for 30 s, 53°C for 30 s, 72°C for 1–2 min with a final

FIG. 1—Phylogenetic tree inferred from partial TEF1 sequences of *Morchella* spp., using the Neighbor Joining method. Posterior probabilities and bootstrap values are given on each node of the tree; the values for poorly supported nodes (bootstrap <40) are enclosed in parentheses. The new Pakistani sequence is set in bold font.


M. sp. HM056335
M. sp. JN085100
M. fekeenis JN085077
0.99/100
M. fekeenis JN085074
M. fekeenis JN085058
M. brunnea GU551397
0.88/71
M. brunnea GU551385
M. brunnea GU551378
M. brunnea GU551377
M. pulchella KM491180
M. septentrionalis KM491186
M. septentrionalis KM491187
0.96/45
M. septentrionalis JN084942
(0.93/34)
M. pulchella HM056344
M. pulchella JQ321857
M. pulchella JN085057
M. pulchella HM056341
(0.74/19)
M. pulchella MF400857
M. pulchella JN085068
M. sp. GU551544
M. sp. GU551381
(0.75/30)
M. sp. GU551390
M. conifericola JN085084
M. conifericola JN085071
0.95/68
0.005
0.97/62
M. conifericola JN085069
0.99/68
M. conifericola JN085060

extension at 72°C for 7 min. Raw sequence data were edited using BioEdit (Hall 1999), assembled with Codon Code Aligner 4.1.1, and deposited in GenBank.

Sequences were analyzed using the BLASTn analysis tool (www.ncbi.nlm.nih.gov). Our newly generated TEF1 sequence plus 26 TEF1 sequences representing *Morchella* species previously deposited in NCBI were used for the phylogenetic analysis. DNA sequences were aligned using Muscle E multiple alignment tool within MEGA v. 7.0 (Kumar & al. 2016). A phylogenetic tree was inferred using the Neighbour-Joining method. Posterior probabilities were determined and the bootstrap analysis was based on 1000 pseudo-replicates using the NJ option.

Results

BLASTn analysis using the TEF1 sequence (Fig. 1) as query matched three GenBank sequences representing *M. pulchella* (KM491180: 100% identity, 636/636 bp) and an unidentified *Morchella* sp. (GU551381: 100% identity, 636/636 bp; GU551390: 99% identity, 635/636 bp).

Similarly, the RPB1 sequence matched three GenBank sequences representing *M. septentrionalis* (KM588048 & JX173414: 100% identity, 785/785 bp) and *M. pulchella* (HM056439: 100% identity, 785/785 bp).

Finally, the RPB2 sequence matched three GenBank sequences representing *M. pulchella* (KM588041, 100% identity, 809/809 bp) and *M. septentrionalis* (KM588048 & JX173414: 100% identity, 805/805 bp).

Taxonomy

Morchella pulchella Clowez & Franç. Petit,
Bull. Soc. Mycol. Fr. 126: 314. 2012. Fig. 2

Ascomata 60–70 × 52–56 mm, conical, brown. Hymenophore 50 × 40 mm, slightly conical, ridged with 26 primary ridges per ascoma, ridges regular to irregular in shape, 2–5 mm long, 3 mm broad, pitted, pits (n = 55–60) short and elongated. Fertile area sharply attached to the stipe. Stipe hollow, white, convex, tapered at apex and wider at base with short rays. Ascospores 20.4–24 × 13–15.6 µm, ellipsoid, smooth, with homogenous contents. Asci 8-spored, cylindrical, hyaline, 200–260 × 15–20 µm, length/width (Qm) ratio 1.5 µm. Paraphyses shorter than asci, 78–150 × 10–14 µm, cylindrical, subclavate, apices rounded, narrow, mostly subacute, rarely acute, septate, hyaline with homogenous contents; yellow hyphal elements on sterile ridges 77–181 × 7.9–26 µm.

Material examined—**PAKISTAN, Khyber Pakhtunkhwa, Swat District**, Malam Jabba, 34°47′54″N 72°34′33″E, altitude 1800 m, under *Pinus wallichiana* A.B. Jacks. and local grasses, 15 April 2015, coll. Hussain Badshah B10 (ISL-67968; GenBank MF400855, MF400856, MF400857).

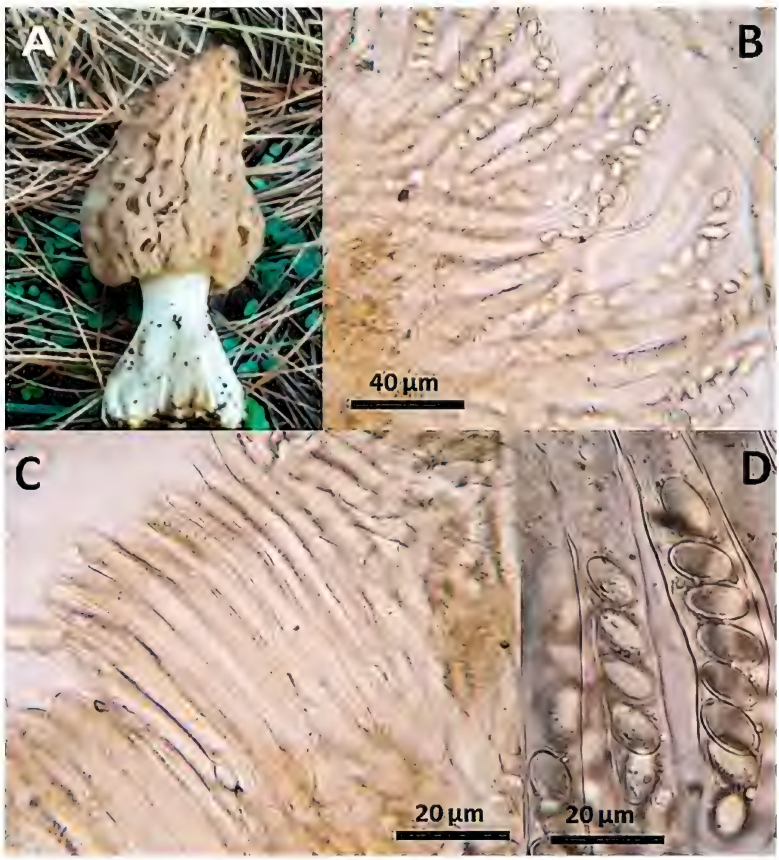


Fig. 2—*Morchella pulchella* (ISL-67968)
A: ascocarp. B, D: asci with ascospores. C: paraphyses.

Discussion

The phylogenetic analysis (Fig. 1) clustered sequences from our collection with *M. pulchella*, supporting the Malam Jabba specimen as a new record of that species from Pakistan. As in previous studies (Du & al. 2012, Taşkın & al. 2012, Richard & al. 2015), our phylogenetic analysis provides no support for the reciprocal monophyly of *M. pulchella* and *M. septentrionalis* and emphasizes the need to investigate further the taxonomic status of *M. pulchella* and *M. septentrionalis*.

Morchella pulchella has previously been reported only from China (Du & al. 2012a,b), Turkey (Taşkin & al. 2010), France (Clowez 2012, Richard

& al. 2015), and Spain (Alonso & al. 2016). Confirmation of *M. pulchella* from an apparently undisturbed mountainous site in Pakistan suggests that *M. pulchella* is unlikely to have been introduced to this region through human activity and has an innately Eurasian distribution.

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Regional annotated mycobiota new to the Mycotaxon website

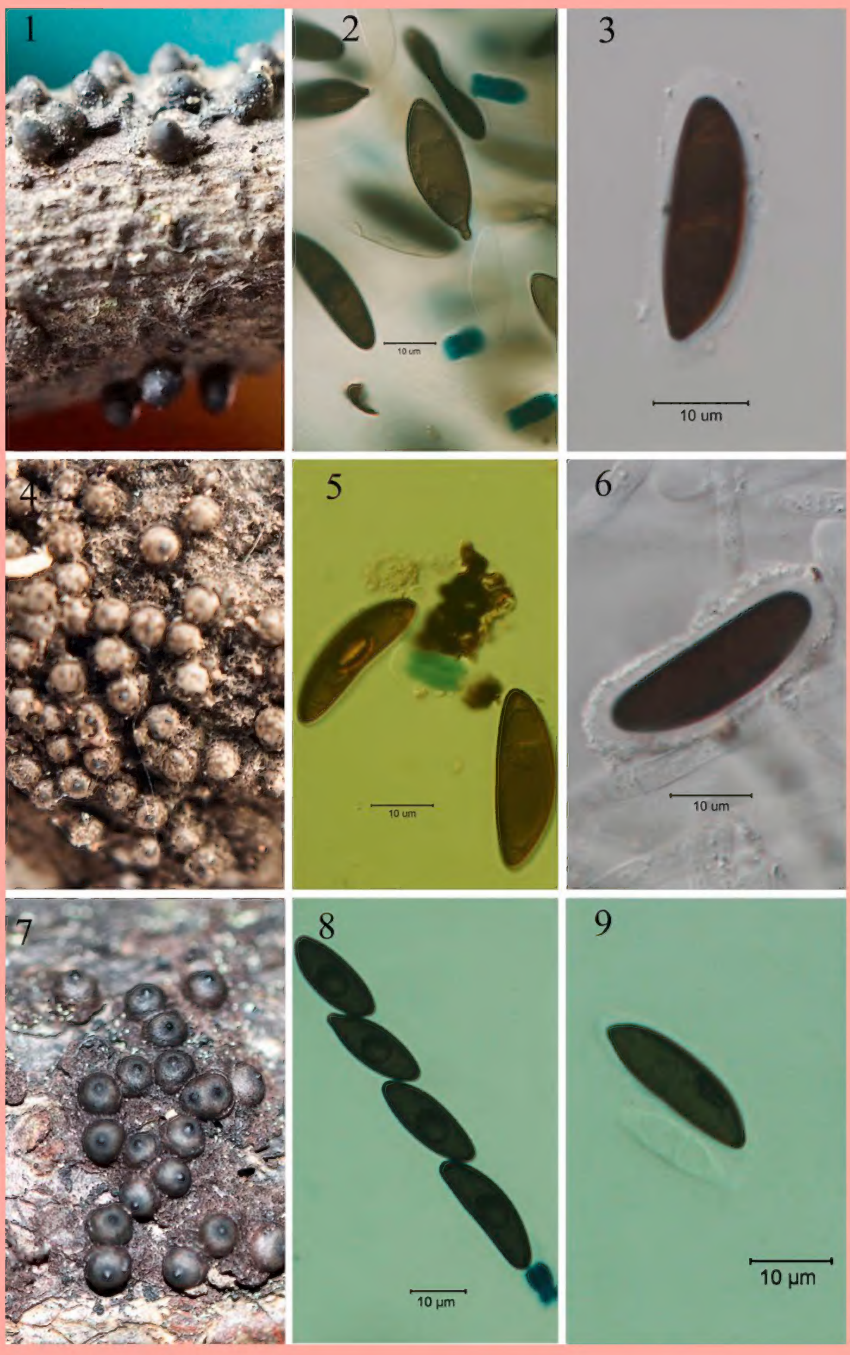
Abstract—Mycotaxon is pleased to add to our 'web-list' page the following new species distribution list under South America (Brazil): Updates on the knowledge of arbuscular mycorrhizal fungi (*Glomeromycotina*) in the Atlantic Forest biome—an example of very high species richness in the Brazilian landscape by Khadija Jobim, Xochitl Margarito Vista, and Bruno Tomio Goto. This brings to 128 the number of free access mycobiotas now available on the re-named Mycotaxon website:
http://www.mycotaxon.com/mycobiotas

South America

Brazil

Khadija Jobim, Xochitl Margarito Vista, Bruno Tomio Goto. Updates on the knowledge of arbuscular mycorrhizal fungi (*Glomeromycotina*) in the Atlantic Forest biome—an example of very high species richness in the Brazilian landscape. 17 p.

Abstract—The Atlantic Forest has historically one of the most sampled biomes on Arbuscular Mycorrhizal Fungi (AMF) diversity in Brazil. Due to the high number of studies published in recent decades, the number of species records available in the literature, including new species for science, has increased substantially. In an effort to monitor recent advances, this paper cites additions to the AMF richness in the Atlantic Forest and provides an updated checklist. We verified a selection of species for this landscape, highlighting the Atlantic Forest as the most representative Brazilian biome, as is to be expected for a global diversity hotspot. Since the Atlantic Forest is the Brazilian area most threatened by human impact, most particularly forest fragmentation, this checklist underscores the importance of developing and maintaining conservation policies for the remainder of Brazil.



***Rosellinia jiangxiensis & R. yunnanensis* spp. nov.**
(and *R. leopoldensis* L.E. Petrini in China)
Li & Guo— Figs. 1–9, p. 33